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THE PSYCHOLOGICAL REVIEW

# A MEASUREMENT OF THE LANGUAGE ABILITY OF DEAF CHILDREN

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*Language Ability.*—In the education of the deaf great emphasis is naturally laid upon the acquisition of language. The deaf child is almost entirely dependent upon formal education in acquiring language. Unlike hearing children he does not live in a 'language environment,' he does not acquire unconsciously a great number of words and phrases, and he is therefore dependent upon the instruction of the class-room for the development of language. The literature dealing with the education of the deaf abounds in references to the importance of the acquisition of language, and it may truly be said that of all subjects of instruction in our schools for the deaf, this subject is the one to which most attention is paid and to which most time is devoted. We quote from a course of study prepared by Robert Patterson, principal of the Ohio Institution for the Deaf, published in 1891, a book to which we shall refer later in discussing the Trabue Language Scale. The first words of the preface, written by James W. Knott, superintendent of the Institution, are: "In this school, as in all deaf-mute schools in America, the prime object to be held in view by every teacher, at all times, is to teach the pupils a correct and easy use of written English language. In the world at large, the deaf-mute must depend almost wholly upon his knowledge of the written language

for his means of communication with speaking-hearing people. Without a good knowledge of written English, he is helpless. With such knowledge he can transact the ordinary business of life, and can enjoy that greatest of all pleasures of solitude—reading." The oralist of to-day might substitute or add spoken language, but in either case the emphasis is thrown upon language work. We have not quoted the above as coming from any great authority in the education of the deaf, but merely owing to the fact that we shall refer shortly to this same manual in regard to one method of teaching language which has been so greatly emphasized in the preface of the book. This attitude towards language work has largely dominated the education of the deaf and is a common one at the present time. Johnson has recently emphasized the importance of language in the following words: "But what are these fundamentals? One and one only. Language and then language—spoken, spelled or written—and the power to read, and the power to understand what is read."[1]

Since language work is so important, it was thought that a measurement of the language ability of the deaf might throw some light upon the factors involved in the development of language ability among the deaf. The measurement of language ability might be roughly divided into the measurement of ability to comprehend language on the one hand, and on the other the ability to compose or construct language. The former ability might best be measured by such tests as Thorndike's[2] 'Reading Scales,' or Kelley's[3] 'Silent Reading Tests,' or Woodworth and Wells[4] 'Directions Tests.' This last test was used by Pintner and Paterson[5] to measure the deaf child's ability to comprehend printed

[1] Johnson, R. O., 'What are the Fundamentals?' *American Annals of the Deaf*, 1916, 61, 92–95.

[2] Thorndike, E. L., 'The Measurement of Ability in Reading, Preliminary Scales and Tests,' *Teachers College Record*, 1914, 15, No. 4.

[3] Kelley, F. J., 'The Kansas Silent Reading Tests,' *J. of Ed. Psych.*, 1916, 7, 63–80.

[4] Woodworth, R. S. and Wells, F. L., 'Association Tests,' PSYCHOL. MONOG., 1911, 13, No. 57.

[5] Pintner, R. and Paterson, D. G., 'The Ability of Deaf and Hearing Children to Follow Printed Directions.' To be published shortly in the *Pedagogical Seminary*.

language. Composition ability might best be graded by the Hillegas,[1] or by the Harvard-Newton[2] Scale. A combination of the two factors of comprehension and composition is supplied by the Trabue Language Scale,[3] and it was this test that was chosen in the present work to measure the language ability of deaf children. It was thought that, since only one single test could be employed, the Trabue Language Scale would give the best all-round measurement of language ability.

The Trabue Language Scale is based upon what is generally known in psychology as the Ebbinghaus Completion Method, that is, the filling in of the correct word in a blank space in a sentence. Ebbinghaus[4] seems to have been the first to use this method as a psychological test. It is interesting to note, however, that this device of filling in blanks is a common one among teachers of the deaf as an exercise in language work and one that has been in use at least since the year 1891. In the Course of Study of the Ohio Institution for the Deaf (1891), referred to above, we find this as one of the exercises recommended for first-year work. To quote: "As a means of getting the children into the habit of thinking for themselves, which will ingrain the principles of language in their mental fiber, give them abundant practice in finding appropriate words to fill the blanks; as,

. . . . . sits.
A boy . . . . . .
A cat sees a . . . . . .
Mary . . . . . Edith."

In Second, Third and Fourth Grade work "filling blanks," as this method is called, is recommended as an appropriate exercise in language work.

It will be obvious from this that the Trabue Language

[1] Hillegas, M. B., 'A Scale for the Measurement of Quality in English Composition by Young People,' *Teachers College Record*, 1912, 13, No. 4.

[2] Ballou, F. W., 'Scales for the Measurement of English Compositions,' *Harvard-Newton Bulletins*, Harvard University, 1914, No. 11, p. 93.

[3] Trabue, M. R., 'Completion-Test Language Scales,' *Teachers College Contributions to Education*, 1916, No. 77.

[4] Ebbinghaus, H., 'Ueber eine neue Methode zur Prüfung geistiger Fähigkeiten und ihre Anwendung bei Schulkindern,' *Zsch. f. Psychol.*, 1897, 13, 401–459.

Scale is eminently fitted for testing the language ability of deaf children. The form of the test is not new to them and therefore any initial strangeness due to the peculiar form of a psychological test will not enter into this test. Indeed, in this respect they will have an advantage over the hearing children, for we do not believe that this method is commonly in use in language work in hearing schools.

*The Method of Procedure.*—Scale *A* of the Trabue Language Scale was used in this study. It consists of twenty-four sentences grouped in pairs of comparatively the same difficulty. The pairs become progressively difficult as we proceed from the first to the last pair.

The subjects tested were 570 deaf pupils, 242 in the Kentucky State School for the Deaf, and 328 in the Ohio State School for the Deaf.[1] The method of procedure in giving the test was to give each pupil in the class the preliminary practice sheet, as recommended by Trabue for work with small children. This practice sheet contains four simple sentences, in each of which there is a blank space which requires an appropriate word. The experimenter wrote the first sentence on the board and asked the class what they would write in to complete the sentence. In most cases the correct answer was forthcoming, but if not, the experimenter wrote in the correct word himself and then instructed the children to do this on their sheets. It was emphasized again and again that only one word was to be written in each blank space. The same procedure was followed with the other three sentences. The practice sheets were then collected, and the test sheets proper were distributed. The first page of the sheets of Scale *A* contains three practice sentences and the children were told to fill in appropriate words. The name, grade, and age of the child is also asked for on this first page and in the same method of filling in blanks. The pupils were allowed as much time as they required to fill in this first page, and while they were at work

[1] The writers take great pleasure in acknowledging here the kindness and courtesy shown to them by Mr. Jones, superintendent of the Ohio State School for the Deaf, and Mr. Augustus Rogers, superintendent of the Kentucky State School for the Deaf.

the examiner went around the class helping those who encountered any difficulty. After this was completed, a signal was given and the children turned over to page two of the test sheet and began the test proper. At the end of 15 minutes they were all required to stop. This time limit of 15 minutes is in most cases too long for deaf children. Nearly all of them had finished long before the 15 minutes had elapsed, owing to the fact that most of them were unable to accomplish very much. With those who possess a good mastery of language, this period of time is adequate for them to complete the whole test.

The method of scoring adopted was that used by Trabue,[1] *i. e.*, a score of two is allowed for a good sentence, a score of one for a fair completion, and no score for an inadequate completion. The examples given by Trabue were referred to constantly in order to determine the score for each sentence. The sum of the scores for all the sentences attempted represents the final score for the child.

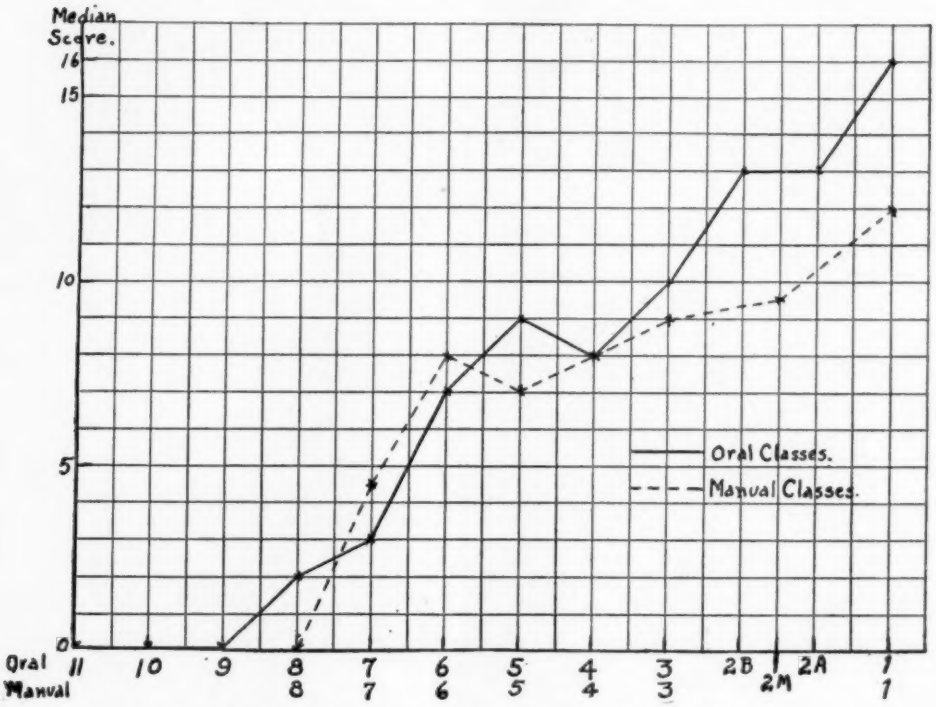
## The Results

*Comparison by Classes.*—The first tabulation of the results was made according to classes. The two schools in question are combined schools. Two methods of instruction are employed, namely, the oral method which teaches by means of speech and lip-reading, and the manual method which makes use of signs and the manual alphabet. The results of these two groups of classes have been kept separately and will be referred to as oral and manual classes respectively.

Graphs I. and II. show the class medians for the two schools for each class and for each of the two methods of instruction. In Graph I. (the Kentucky School) it will be noted that with two exceptions the manual classes are somewhat below the oral classes. Only in the two upper classes is the difference in language ability very marked. The curve for the oral classes shows one drop at the fourth class, but it must be borne in mind that the fourth and fifth classes are

[1] Trabue, *op. cit.*, 79–115.

parallel classes doing the same year's work. The medians of these two classes would suggest that there is one relatively slow and one relatively advanced class doing the same year of work. The curve for the manual classes shows a drop at class five. This class is doing a higher year of work than

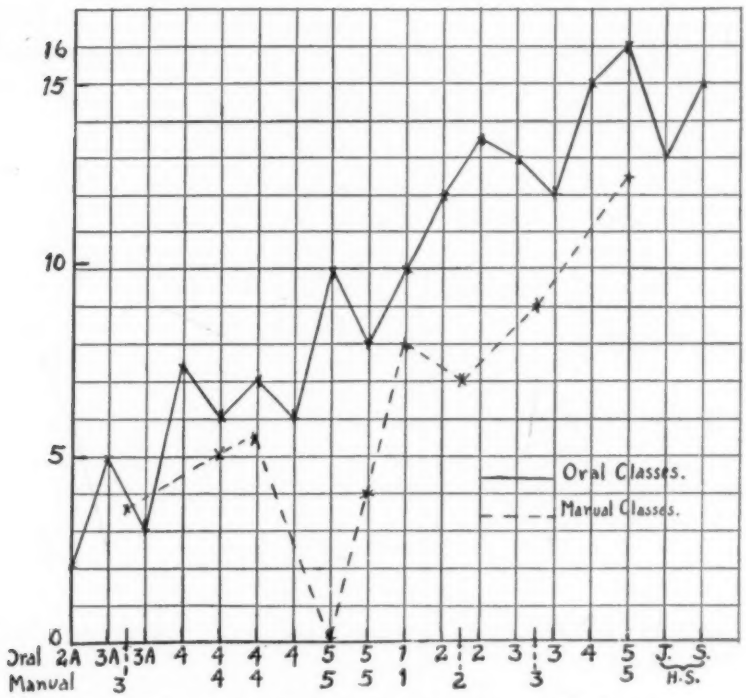



GRAPH I. Showing Medians of the Classes in the Kentucky School

class six. It would seem from the median of class six that this class is good in language ability, since it is better than class five and equal to class four, and both of the latter classes are doing more advanced work than class six.

In Graph II. (the Ohio School) the numbering of the classes is different from that in Kentucky. In this school all classes doing the same year of work are given the same numbers. Both oral and manual curves show decided fluctuations from class to class. Following the oral curve we note that there are two third primary classes of distinctly

different language ability, in other words a poor and a good class. This division into a poor and a good group in the third primary would indicate a good classification of the children. The medians of the four fourth primary classes vary slightly (*i. e.*, the medians are 7.5, 6, 7, 6), but are all close enough together to suggest that, for language work at least, a much better division might be possible whereby the best pupils might be in one section, the poorest in another




GRAPH II. Showing Medians of the Classes in the Ohio School

and the average ones in the two remaining sections. There are 41 pupils in these four classes and if a division as suggested above were to be made, we would have, first, a poor section of 10 with scores from 1 to 4 with a median about 2.5; second, a medium section of 10 with scores from 4 to 6 with a median of 5; third a medium section of 11 with scores from 6 to 7 with a median of 6.5; and lastly a bright section of 10 with

scores from 8 to 12 with a median of 10. The two sections of the fifth primary show a good and a weak section, as is also the case with the two sections of the second intermediate. The two third intermediate sections are both decidedly poor and fall below one of the sections of the second intermediate. There is a peculiar drop in language ability in the two high school classes. It has been suggested that this is due to the entrance into these classes of pupils from the manual classes.

The curve for the manual classes is uniformly below that of the oral. From the results of other tests previously reported,[1] we believe that in this school the difference can be accounted for by the fact that the brighter pupils tend to be chosen for oral work. Following the manual curve we note that the third manual does as well as one of the sections of the third oral, but falls decidedly below the other. The two sections of the fourth manual if divided according to language ability would give a slow section of 12 pupils with scores ranging from 0 to 4 with a median of 2, and a better section of 11 pupils with scores from 5 to 9 with a median of 6. It appears to the writers that division of classes into sections according to ability as measured by tests might decidedly improve the classification and be a decided aid to efficient teaching. The two sections of the fifth manual are evidently well classified into a poorer and a better group, although as far as language is concerned, it seems strange that the one section should be ranked as a fifth manual in as much as its median language ability is zero, *i. e.*, the lowest of any manual class. The second intermediate manual drops below the first intermediate in language ability.

*Comparison by Years of Work.*—The course of study in the two schools extends over thirteen years of work. The next comparison, therefore, that was made, was a comparison of

[1] Pintner, R. and Paterson, D. G., 'Learning Tests with Deaf Children,' PSYCHOL. MONOG., 1916, **20**, No. 88.

Pintner, R. and Paterson, D. G., 'A Class Test with Deaf Children,' *J. of Educ. Psychol.*, 1915, **6**, No. 10.

Pintner, R. and Paterson, D. G., 'A Comparison of Deaf and Hearing Children in Visual Memory for Digits,' *J. of Exp. Psychol.* To appear shortly.

the language ability of the pupils grouped according to the year of work. These results are given in Tables I., II., and III.

Table I. gives the data for the oral pupils for each school. The vertical columns show the year of instruction, from the

TABLE I

ORAL PUPILS: BY YEARS OF WORK

| | | Years of Work | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |
| Number Tested.. | Ohio. | — | — | 9 | 15 | 22 | 25 | 12 | 28 | 41 | 22 | 13 | — |
| | Ky. . | — | 9 | — | — | — | 23 | 12 | 22 | 11 | 21 | 26 | 13 |
| Median . | Ohio. | — | — | 16 | 15 | 12.5 | 13 | 10 | 8.5 | 6 | 5 | 2 | — |
| | Ky. . | — | 16 | — | — | — | 13 | 10 | 9 | 9 | 2 | 0 | 0 |
| 25 per-centile | Ohio. | — | — | 13.25 | 14.0 | 10 | 9.25 | 6 | 7 | 4 | 1 | 0.25 | — |
| | Ky. . | — | 12 | — | — | — | 11 | 10 | 7.15 | 8 | 2 | 0 | 0 |
| 75 per-centile | Ohio. | — | — | 20.75 | 19.75 | 16 | 16.5 | 13 | 10 | 7.75 | 7.5 | 4 | — |
| | Ky. . | — | 24 | — | — | — | 14 | 11.5 | 11 | 10.25 | 4 | 0.5 | 4.5 |
| Quartile. | Ohio. | — | — | 3.8 | 2.8 | 3.0 | 3.6 | 3.5 | 1.5 | 1.9 | 3.3 | 1.9 | — |
| | Ky. . | — | 6 | — | — | — | 1.5 | 1.2 | 1.7 | 1.2 | 1 | 0.25 | 2.2 |
| Grade Ability.. | Ohio. | — | — | 4.5 | 4.25 | 3.7 | 3.8 | 3.3 | 3.1 | 2.5 | 2.25 | −2 | — |
| | Ky. . | — | 4.3 | — | — | — | 3.8 | 3.4 | 3.2 | 3.2 | −2 | −2 | −2 |

thirteenth down to the second. It was found impracticable to test any of the first-year pupils. The first two horizontal columns give the number of pupils in each year of instruction. The second two give the medians. Here it will be noted that there is a much more uniform increase from year to year than was observed in the graphs showing the medians of the various classes. On the whole the medians show little difference in language ability in the two schools. The greatest difference occurs in the fourth year, where the median for Ohio is 5 and for Kentucky only 2. The next two horizontal columns show the 25 and 75 percentiles. The 25 percentile is the highest score made by the lowest 25 per cent. of the group while the 75 percentile represents the highest score attained by 75 per cent. of the group. The 25 percentile seems on the whole to be somewhat lower for Ohio than for Kentucky; and the 75 percentile seems on the whole somewhat higher for Ohio than for Kentucky. This indicates a wider range in the Ohio groups and this is borne out by the quartiles in the next horizontal columns. With one minor

exception these are all higher for Ohio than for Kentucky. The last two columns compare the median for each year of work with the median grade ability of hearing classes as tested by Trabue. In these columns the grade ability of hearing children which corresponds to the medians for the deaf is given. Deaf children in the tenth, eleventh, and twelfth years of work exceed slightly the median language ability of fourth-grade hearing children. A grade ability of $-2$ indicates that the median for the deaf has not reached the median for second-grade hearing children. This is the lowest grade in hearing schools reported by Trabue. This comparison with hearing children brings into sharp relief the difficulty that deaf children experience in the acquisition of language and will be further commented upon below.

Table II. gives similar data for the manual pupils arranged according to years of work. The medians for these pupils

TABLE II

MANUAL PUPILS: BY YEARS OF WORK

| | | Years of Work | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |
| Number Tested.. | Ohio | — | — | 12 | — | 13 | 12 | 13 | 26 | 23 | 16 | — | — |
| | Ky. | — | 7 | — | 8 | 14 | 16 | 15 | 18 | — | 14 | — | 13 |
| Median . | Ohio | — | — | 12.5 | — | 9 | 7 | 8 | 3 | 5 | 3.5 | — | — |
| | Ky. | — | 12 | — | 9.5 | 9 | 8 | 7 | 8 | — | 4.5 | — | 0 |
| 25 per-centile . | Ohio | — | — | 6 | — | 7 | 6 | 6 | 0 | 2 | 1 | — | — |
| | Ky. | — | 10.5 | — | 8 | 8 | 6.5 | 5.5 | 6 | — | 2 | — | 0 |
| 75 per-centile . | Ohio | — | — | 14 | — | 10 | 8 | 9.75 | 5 | 6.25 | 5 | — | — |
| | Ky. | — | 14 | — | 11 | 12 | 9.5 | 8 | 10 | — | 6 | — | 0 |
| Quartile. | Ohio | — | — | 4.0 | — | 1.5 | 1.0 | 1.9 | 2.5 | 1.6 | 2 | — | — |
| | Ky. | — | 2.2 | — | 1.5 | 2 | 1.5 | 1.2 | 2 | — | 2 | — | — |
| Grade Ability.. | Ohio | — | — | 3.77 | — | 3.17 | 2.75 | 3 | −2 | 2.25 | −2 | — | — |
| | Ky. | — | 3.6 | — | 3.2 | 3.2 | 3 | 2.75 | 3 | — | 2 | — | −2 |

do not show quite such a steady increase from year to year as is the case with the oral pupils. The quartiles for Ohio are not so large as for the oral pupils, indicating that the range of ability with the manual pupils at each year of work is not so great. The comparison with the grade ability of hearing children shows that no group of manual pupils reaches a fourth-grade ability in language. The somewhat inferior performance of the manual pupils as noted on Graphs I.

and II. is brought out again in the comparison shown in this table.

Table III. shows the combined results of both schools divided as to oral and manual pupils. Though the number

TABLE III

OHIO AND KENTUCKY COMBINED

*Oral Pupils: By Years of Work*

| | Years of Work | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |
| Number | — | 9 | 9 | 15 | 22 | 48 | 24 | 50 | 52 | 43 | 39 | 13 |
| Median | — | 16 | 16 | 15 | 12.5 | 13 | 10 | 9 | 7 | 3 | 0 | 0 |
| 25 percentile | — | 12 | 13.25 | 14.0 | 10 | 11 | 6 | 7 | 5 | 1 | 0 | 0 |
| 75 percentile | — | 24 | 20.75 | 19.75 | 16 | 15 | 13 | 10.75 | 8 | 6 | 2 | 4.5 |
| Quartile | — | 6 | 3.8 | 2.8 | 3.0 | 2.0 | 3.5 | 1.9 | 1.5 | 2.5 | 1.5 | 2.2 |
| Grade ability | — | 4.5 | 4.5 | 4.25 | 3.7 | 3.8 | 3.3 | 3.2 | 2.75 | −2 | −2 | −2 |

*Manual Pupils: By Years of Work*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | — | 7 | 12 | 8 | 27 | 28 | 28 | 44 | 23 | 30 | 0 | 13 |
| Median | — | 12 | 12.5 | 9.5 | 9 | 8 | 7 | 5 | 5 | 4 | — | 0 |
| 25 percentile | — | 10.5 | 6 | 8 | 7 | 6 | 6 | 1 | 2 | 2 | — | 0 |
| 75 percentile | — | 14 | 14 | 11 | 10 | 9 | 9 | 8 | 6.25 | 5.5 | — | 0 |
| Quartile | — | 2.2 | 4.0 | 1.5 | 1.5 | 1.5 | 1.5 | 3.5 | 1.6 | 1.8 | — | 0 |
| Grade ability | — | 3.6 | 3.8 | 3.2 | 3.2 | 3 | 2.75 | 2.25 | 2.25 | 2 | — | −2 |

under each year of work is not great, the medians may serve as tentative norms of language ability for oral and manual children. In a combined school an oral pupil in the ninth year of work might be expected to make a score of 12.5 and a manual pupil in the same year a score of 9, and so on. It will be noted that with both groups of pupils the medians show an almost steady increase from year to year. Looking at the last horizontal column giving the comparison with hearing schools, we might say that the oral pupil advances from second-grade ability in his fourth or fifth year of schooling to somewhat above fourth-grade ability in his twelfth year of instruction. A manual pupil's progress seems to be slower, advancing only to somewhat above third-grade ability in his twelfth year of instruction.

Table IV. shows the combined results for all the 570 children tested, and we may regard these as tentative norms or all deaf, regardless of method of instruction. The in-

TABLE IV

ALL DEAF: BY YEARS OF WORK

| | Years of Work | | | | | | | | | | | | All Deaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | |
| Number | 7 | 35 | 21 | 23 | 49 | 76 | 52 | 94 | 75 | 73 | 39 | 26 | 570 |
| Median | 15 | 13 | 14 | 14 | 10 | 11 | 8 | 7.5 | 6 | 3 | 0 | 0 | 7 |
| 25 percentile | 13.5 | 11 | 11.25 | 9.75 | 8 | 8 | 6 | 4.5 | 4 | 2 | 0 | 0 | 4 |
| 75 percentile | 26.0 | 15.75 | 17.5 | 18.5 | 13 | 14 | 10 | 10 | 8 | 6 | 2 | 2 | 11 |
| Quartile | 6.7 | 2.4 | 3.1 | 4.4 | 2.5 | 3 | 2 | 2.8 | 2 | 2 | 1 | 1 | 3.5 |
| Grade ability | 4.25 | 3.8 | 4.0 | 4.0 | 3.3 | 3.5 | 3 | 2.8 | 2.5 | −2 | −2 | −2 | 2.75 |

crease in the median from year to year is not quite uniform and this would lead us to suspect a lack of definite standards of work required at the different institutions and in the different divisions (oral and manual) in the same institution. In language ability at least no very definite standard seems to be set up to which the pupil must approximate before he is allowed to go on with the next year's work. This fact is borne out by the large quartiles, and they are particularly large in the upper years. We would raise the question as to the desirability of setting up more definite standards of attainment for each year of work in the interest of more efficient instruction in any one school, and of a more definite understanding between schools as to what a year of work in any subject means, with a view of ultimately bringing about a better standardization of schools. Comparisons between schools would in this way be better and more justly made, and the transfer of a pupil from one school to another would be effected with less waste of time in determining his proper grade.

The comparison of the deaf child with the hearing child, as shown on the last line, brings out strikingly the poverty of language attainment among the deaf. After thirteen years of instruction the language ability of the average deaf child does not reach that of a fifth-grade pupil in our hearing schools. There are, as we shall see later, quite a number of cases that go beyond this ability, but, nevertheless, the average remains at this low score. Up to the fourth year of instruction the average ability does not rise to that of a second-grade hearing child. From this point on, it creeps

slowly up to third- and fourth-grade ability. This comparison shows better than any we have seen the great difficulty the deaf must experience in the acquisition of the language of the hearing. In spite of the great emphasis placed upon language in the teaching of the deaf, the progress of the pupil is incredibly slow. We must remember, of course, that the acquisition of language by a deaf child is somewhat analogous to the acquisition of a foreign language by a hearing child. If the data were at hand, it would be interesting to compare the rate of acquisition of language by the deaf with the rate of acquisition of a foreign language by a hearing child not living in the country in which the foreign language is spoken.

*Comparison of Adventitious and Congenital Deaf.*—The comparison between the adventitious and congenital is made for the two schools combined, since there is nothing to be gained from this comparison for each of the two schools taken separately. Table V. gives the distribution for these

TABLE V

ALL DEAF: COMPARISON OF CONGENITAL AND ADVENTITIOUS CASES

*Congenital Cases: By Years of Work*

| | Years of Work | | | | | | | | | | | | All Cong. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | |
| Number... | 1 | 16 | 6 | 7 | 16 | 31 | 22 | 42 | 33 | 37 | 22 | 17 | 250 |
| Median.... | 14 | 13 | 12 | 11 | 9 | 11 | 8 | 7.5 | 6 | 3 | 0 | 0 | 7 |
| 25 per-centile... | — | 11 | — | — | 7 | 8 | 7 | 5 | 4 | 1.25 | 2.5 | 0 | 3 |
| 75 per-centile... | — | 14 | — | — | 11 | 13 | 11 | 9.5 | 8 | 5.75 | 0 | 0 | 10 |
| Quartile ... | — | 1.5 | — | — | 2 | 2.5 | 2 | 2.3 | 2 | 2.3 | 1.3 | 0 | 3.5 |
| Grade ability... | 4.0 | 3.85 | 3.7 | 3.5 | 3.2 | 3.5 | 3 | 2.8 | 2.5 | −2 | −2 | −2 | 2.75 |

*Adventitious Cases: By Years of Work*

| | Years of Work | | | | | | | | | | | | All Ad. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | |
| Number... | 6 | 19 | 15 | 12 | 30 | 45 | 29 | 50 | 38 | 34 | 14 | 9 | 301 |
| Median.... | 15 | 13 | 14 | 16 | 11 | 11 | 8 | 8 | 6.5 | 4 | 0 | 0 | 8 |
| 25 per-centile... | — | 10.5 | 11 | 10 | 9 | 7.5 | 6 | 4 | 4 | 1.5 | 0 | 0 | 4 |
| 75 per-centile... | — | 18.25 | 20 | 22 | 13.5 | 14.5 | 10 | 10 | 8 | 6 | 2 | 2 | 12 |
| Quartile ... | — | 3.8 | 4.5 | 6 | 2.3 | 3.5 | 2 | 3 | 2 | 2.3 | 1 | 1.0 | 4 |
| Grade ability... | 4.25 | 3.8 | 4.0 | 4.5 | 3.5 | 3.5 | 3 | 3 | 2.6 | 2 | −2 | −2 | 3 |

TABLE VI

ALL DEAF, ARRANGED ACCORDING TO TIME WHEN DEAFNESS OCCURRED

| | Cong. | Un-known | Ac. | Before 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | 250 | 19 | 20 | 45 | 85 | 65 | 32 | 19 | 11 | 10 | 1 | 0 | 2 | 3 | 2 | 2 | 2 | 1 | 1 |
| Median | 7 | 6 | 8.5 | 8 | 7 | 6 | 9 | 10 | 14 | 12 | 10 | — | 20 | 17 | 20 | 15.5 | 35 | 26 | 23 |
| 25 percentile | 3 | 1.5 | 6 | 0.5 | 4 | 4 | 4 | 7.5 | 6 | 8.5 | — | — | — | — | — | — | — | — | — |
| 75 percentile | 10 | 13.5 | 11 | 10 | 11 | 11 | 13 | 17 | 15.75 | 26.5 | — | — | — | — | — | — | — | — | — |
| Quartile | 3.5 | 6.0 | 2.5 | 4.8 | 3.5 | 3.5 | 4.5 | 5.2 | 4.8 | 9.0 | — | — | — | — | — | — | — | — | — |
| Grade ability | 2.75 | 2.5 | 3.1 | 3 | 2.75 | 2.5 | 3.2 | 3.3 | 4 | 3.7 | 3.3 | — | 5.7 | 4.75 | 5.7 | 4.3 | 11.0 | 7.25 | 6.5 |

two groups of deaf children arranged as before according to years of instruction. An inspection of the medians for the two groups shows that at every year of work the adventitious group is either better or at least equal to the congenital group. In the twelfth, eighth, seventh, third, and second year of work the medians for the two groups are the same; in all the other years the median of the adventitious is higher than that of the congenital group. This somewhat better showing of the adventitious is, of course, reflected in a somewhat higher grade ability in comparison with the hearing child. The median score of all the congenital cases taken together is 7, whereas the median for the adventitious is 8.

*Time of Occurrence of Deafness.*—The slightly better showing of the adventitious group leads us to raise the further question as to whether the time at which deafness occurred has any relation to the language ability of the child. It is generally held by teachers of the deaf that a few years of hearing or even a few months has a decided influence for the better in the acquisition of language by the deaf child. Table VI. gives the results of our test from this point of view. The first vertical column gives the results for all the congenital cases; the second column, headed 'unknown,' for those cases where the cause of deafness, whether congenital or adventitious, was not known; the third column for the acquired cases

where the year at which deafness occurred was doubtful or unknown. The remaining columns show a distribution according to the year at which deafness occurred. 'Before I.' means all cases of deafness occurring before the first birthday. 'One' means cases occurring between the first and second birthday and so on. In the upper groups, showing the occurrence at age seven or later, there are relatively few cases in any one group. An inspection of the medians shows little difference between the congenital group and the adventitious groups up to age four. In these first eight groups on the table, the median ranges from 6 to 10. Ages three and four show a very slight increase above the score of the congenital group, an increase which may be due to their once having possessed hearing, but the increase is so slight as not to warrant any dogmatic statement. At age five an increase of 4 points over age four takes place. From this point on (with the exception of age seven represented by only one case), there is a very decided but irregular and fluctuating increase in the medians. These results might lead us to some such tentative generalization as follows: Children who lose their hearing before the age of four or five are very little, if at all, benefited, as far as language ability is concerned, by having once possessed hearing. Further, every year of hearing after the age of four seems to increase the chances for a better acquisition of language. By language we mean here the ability to understand and compose. Our data has nothing to offer in regard to the ability to speak, read the lips or communicate by means of signs and the manual alphabet. The higher medians for those who become deaf in later childhood are reflected in the much higher grade ability as contrasted with hearing children. It will be remembered that the deaf as a group never reach fifth-grade ability. In the last column of Table VI. it will be noted that some of the groups go beyond fourth-grade ability, one reaching the level of eleventh-grade ability.

*Comparison of Hearing and Deaf.*—To bring out further the contrast between the hearing and the deaf in this test, we have constructed Table VII. This shows the number

## TABLE VII

DISTRIBUTION ACCORDING TO HEARING GRADE ABILITY

| Grade | Kentucky | | | | | | Ohio | | | | | | Ohio and Ky. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oral | | Manual | | All Deaf | | Oral | | Manual | | All Deaf | | All Deaf | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| −2 | 34 | 27.4 | 6 | 6.5 | 40 | 18.5 | 20 | 10.7 | 24 | 20.9 | 44 | 13.4 | 84 | 15.5 |
| 2 | 21 | 16.9 | 26 | 28.3 | 47 | 21.8 | 42 | 22.4 | 45 | 39.1 | 88 | 26.8 | 135 | 24.8 |
| 3 | 42 | 33.8 | 47 | 51.1 | 89 | 41.2 | 61 | 32.6 | 36 | 31.3 | 111 | 33.8 | 200 | 36.8 |
| 4 | 20 | 16.1 | 12 | 13.0 | 32 | 14.8 | 46 | 24.6 | 8 | 7.0 | 59 | 18.0 | 91 | 16.7 |
| 5 | 1 | 0.8 | 1 | 1.1 | 2 | 0.9 | 8 | 4.3 | 1 | 0.9 | 12 | 3.7 | 14 | 2.6 |
| 6 | 2 | 1.6 | ... | ..... | 2 | 0.9 | 3 | 1.6 | 1 | 0.9 | 5 | 1.5 | 7 | 1.3 |
| 7 | 2 | 1.6 | ... | ..... | 2 | 0.9 | 3 | 1.6 | ... | ..... | 3 | 0.9 | 5 | 0.9 |
| 8 | 1 | 0.8 | ... | ..... | 1 | 0.5 | 2 | 1.1 | ... | ..... | 2 | 0.6 | 3 | 0.6 |
| 9 | 1 | 0.8 | ... | ..... | 1 | 0.5 | 1 | 0.5 | ... | ..... | 1 | 0.3 | 2 | 0.4 |
| 10 | ... | .... | ... | ..... | ... | ..... | ... | .... | ... | ..... | ... | .... | ... | ..... |
| 11 | ... | .... | ... | ..... | ... | ..... | ... | .... | ... | ..... | ... | .... | ... | ..... |
| 12 | ... | .... | ... | ..... | ... | ..... | 1 | 0.5 | ... | ..... | 1 | 0.3 | 1 | 0.2 |
| College Graduates | ... | .... | ... | ..... | ... | ..... | ... | .... | ... | ..... | 2 | 0.6 | 2 | 0.4 |
| Total | 124 | 99.6 | 92 | 100.0 | 216 | 100.0 | 187 | 99.6 | 115 | 100.1 | 328 | 99.9 | 544 | 100.2 |

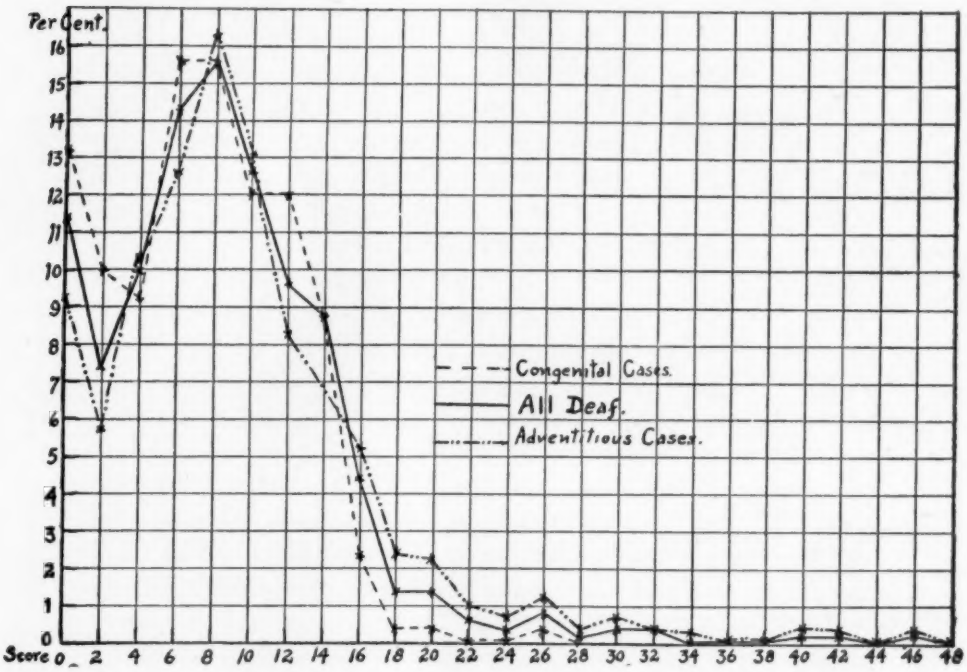
and per cent. of pupils having scores equivalent to each grade ability of hearing children. All those having a score less than 3 were counted as −2 or below second-grade ability. The median for grade 2 for hearing children is 4, and we have included in second-grade ability all those having scores from 3.1 to 6. The third-grade median is 8 and we have counted as third-grade ability all cases having scores from 7 to 11. In other words the grade ability was taken to include all scores lying between the score midway between the grade in question and the grade below up to the score lying midway between the grade in question and the grade above. The table shows the results for Ohio, for Kentucky and for both schools combined. Further the division into oral and manual pupils is shown. In this table the results for the second year's work were omitted, since only the second-year pupils in one school were tested. The inclusion of this group in one school alone would have spoiled a fair comparison by means of percentages.

In both schools the percentage of pupils in the oral classes who reach a high grade ability is much greater than in the manual classes. No manual pupil in Kentucky goes beyond

fifth-grade ability, in Ohio beyond sixth-grade ability. One oral pupil in Kentucky reaches ninth-grade ability, in Ohio twelfth-grade ability. Comparing the percentages in the "All Deaf" columns for the two schools we note a somewhat larger percentage in Kentucky making a score below second-grade ability. The largest percentage at any one grade ability occurs at the third-grade ability in both schools, but the percentage for Kentucky is higher than that for Ohio. From fourth-grade ability onwards the percentage at each step is always higher in the Ohio school. Under the "All Deaf" in Ohio are included 26 high-school pupils who could not be classified as either oral or manual, and who were therefore omitted from the oral and manual columns. The columns for all the deaf of both schools show that third-grade ability occurs most frequently, accounting for 36.8 per cent. of the total tested. Second-grade ability comes next in order of frequency; then fourth-grade ability and minus second-grade ability. The rest of the cases are scattered over higher grade abilities, showing at no point a percentage higher than 2.6. It should be noted that two pupils in the high-school grades in the Ohio school make scores equal to the median for college graduates. The total scattering in grade abilities above the fourth grade amounts in all to only 6.4 per cent. of the pupils tested. All these facts serve but to emphasize what we have said above about the poverty of language exhibited by the deaf child.

*Distribution of Scores.*—The percentage distribution of the scores made by the pupils is shown on Graph III. The base line represents the scores. The first point on the line shows the per cent. making a score of zero. At the point marked 2 all making a score of 1 or 2 are shown, at the point 4 all making a score of 3 or 4, and so on, each point along the base line including two points of the score. The solid line shows the results for all the cases. A score of zero is made by 11.4 per cent. of the cases. There is then a drop in the number making a score of 1 or 2. The curve rises steadily to a percentage of 15.6, making a score of 7 or 8. This is the most common of any one score made by the pupils. From

this point the percentage of pupils drops steadily to a score of 17 or 18, which is attained by a percentage of 1.4. After this point the percentage of cases at any one point of the curve never rises above one per cent. The broken line curve shows the percentages for the congenital cases and the dotted




GRAPH III. Distribution of Scores of the Congenitally Deaf, Adventitiously Deaf, and All Deaf

and broken line curve for the adventitious cases. It will be seen at once that the curve for the congenitals shows a greater number of cases at the lower scores, while the curve for the adventitious shows fewer cases than the congenitals at the lower scores and a greater number at the higher scores. Indeed the congenital curve stops at the point 25–26, whereas the adventitious shows a scattering of cases up to the 45–46 point. This is, of course, to be expected in view of our previous analysis of the performance of the two groups. However, it should be noted that there are cases of congenital pupils who make fairly high scores, notably the one case at

the 25–26 point. The boy making this score is probably well above the average deaf pupil in mentality. His score is equal to seventh-grade ability. It is perfectly possible, therefore, for a congenitally deaf child to attain a good command of language, but we are led to believe from the results as a whole that this will only be the case with pupils possessing exceptional mentality and a favorable environment. All the other high scores have been made by adventitious cases, and these are the cases where deafness occurred in later childhood.

*Relative Difficulty of Each Sentence.*—The question as to whether the language development of the deaf proceeds along the same lines as that of the hearing can be approached by a study of the relative difficulty of each sentence on the Trabue Scale. This scale represents sentences of progressive difficulty for hearing children. Is the relative difficulty of these sentences the same for the deaf? To answer this question the score made on each sentence by the deaf pupils tested was calculated. In this computation the congenital cases were kept in one group and the adventitious cases in groups according to the time at which deafness occurred. This was done in order to see whether there was any difference in the relative difficulty of the sentences for each of these groups. It was thought possible that the language development of the congenital pupils might proceed along slightly different lines from the language development of the adventitious. These considerations, therefore, resolve themselves into a comparison of the relative difficulty of the sentences for the deaf and the hearing, and further for the different groups of deaf among themselves.

Table VIII. shows the score made by each group of deaf children on each sentence of the scale. These are the actual scores. At the bottom of the table is given the number of children in each group and the perfect score for that group, *i. e.*, the score that would have been made by the group if every child had completed every sentence perfectly.

Table IX. shows the same facts expressed in percentages. The figures in this table show the per cent. that the score made is of the perfect score, and this enables us to make the

## TABLE VIII

SCORES MADE BY EACH GROUP OF DEAF CHILDREN ON EACH SENTENCE OF LANGUAGE SCALE *A*

| Sentence Number | Congenital | Unknown | Acquired† | 0–1 | 1 | 2 | 3 | 4 | 5 | 6 | 7–15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2*x* | 338 | 22 | 32 | 58 | 130 | 94 | 46 | 30 | 18 | 20 | 26 |
| 2*y* | 336 | 26 | 35 | 57 | 123 | 102 | 52 | 36 | 18 | 20 | 28 |
| 3*x* | 261 | 16 | 22 | 43 | 87 | 52 | 36 | 28 | 18 | 17 | 25 |
| 3*y* | 240 | 21 | 26 | 44 | 101 | 66 | 34 | 22 | 16 | 18 | 26 |
| 4*x* | 68 | 8 | 6 | 14 | 30 | 20 | 20 | 20 | 10 | 12 | 18 |
| 4*y* | 272 | 18 | 26 | 47 | 96 | 78 | 46 | 30 | 13 | 16 | 24 |
| 5*x* | 89 | 5 | 12 | 16 | 34 | 20 | 13 | 16 | 10 | 8 | 20 |
| 5*y* | 60 | 7 | 5 | 11 | 17 | 21 | 17 | 8 | 10 | 8 | 20 |
| 6*x* | 13 | 2 | 3 | 2 | 4 | 3 | 7 | 9 | 2 | 8 | 13 |
| 6*y* | 7 | ..... | 2 | 4 | 2 | 7 | 5 | 6 | ... | 6 | 16 |
| 7*x* | 2 | 2 | ..... | ... | 6 | 5 | 6 | 5 | 3 | 7 | 12 |
| 7*y* | 12 | 2 | ..... | 1 | 14 | 5 | 8 | 5 | 1 | 7 | 15 |
| 8*x* | 6 | 3 | 1 | 3 | 4 | 9 | 6 | 7 | 1 | 4 | 12 |
| 8*y* | 3 | ..... | 1 | 1 | 3 | ... | 5 | 5 | ... | 7 | 10 |
| 9*x* | ..... | ..... | ..... | ... | ... | ... | 2 | 2 | ... | 3 | 4 |
| 9*y* | 1 | ..... | ..... | ... | ... | ... | 2 | 1 | ... | 2 | 4 |
| 10*x* | ..... | ..... | ..... | ... | 3 | ... | 2 | 1 | ... | 3 | 6 |
| 10*y* | ..... | ..... | ..... | ... | ... | ... | ... | 4 | ... | 2 | 2 |
| 11*x* | ..... | ..... | ..... | ... | ... | ... | 1 | ... | ... | 2 | 2 |
| 11*y* | ..... | ..... | ..... | ... | 1 | ... | 1 | ... | ... | 2 | 1 |
| 12*x* | ..... | ..... | ..... | ... | ... | ... | 2 | ... | ... | 2 | 1 |
| 12*y* | ..... | ..... | ..... | ... | ... | ... | 1 | ... | ... | 2 | ... |
| 13*x* | ..... | ..... | ..... | ... | ... | ... | ... | ... | ... | 2 | ... |
| 13*y* | ..... | ..... | ..... | ... | ... | ... | 1 | ... | ... | ... | ... |
| No. tested | 250 | 19 | 20 | 45 | 85 | 65 | 32 | 19 | 11 | 10 | 14 |
| Perfect score | 500 | 38 | 40 | 90 | 170 | 130 | 64 | 38 | 22 | 20 | 28 |

comparisons in regard to the relative difficulty of the sentences. Mere inspection of this table shows that the pairs of sentences are roughly equally difficult for the deaf as they have proved to be for hearing children. The only striking exception to this is the pair 4*x*, 4*y*. For the deaf 4*x* is for all groups much more difficult than 4*y*. The difference between these two sentences might be described as a difference between an abstract and a concrete sentence. Sentence 4*y* is: "Boys and ..... soon become ..... and women." Sentence 4*x* is: "Time ..... often more valuable ..... money." The latter may be called more abstract than the former. The latter is relatively more difficult for the deaf than it is for the hearing. Furthermore, sentence 4*x* is somewhat in the nature of a proverb, and is probably heard by the hearing child a great many times in ordinary conversation. We see further from this table that as we proceed from the congenital

group up through the adventitious groups, the percentages for each sentence tend to increase steadily though not uniformly from group to group. This again bears out what we have noted previously as to the superior language ability of

## TABLE IX

PER CENT. SCORE MADE BY EACH GROUP OF DEAF CHILDREN IS OF PERFECT SCORE FOR EACH SENTENCE OF LANGUAGE SCALE *A*

| Sentence Number | Congenita | Unknown | Acquired ? | 0–1 | 1 | 2 | 3 | 4 | 5 | 6 | 7–15 | Total | Average Per Cent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2*x* | 67.5 | 57.9 | 80.2 | 64.5 | 76.5 | 72.2 | 72.0 | 79.0 | 81.7 | 100.0 | 92.9 | 844.4 | 76.76 |
| 2*y* | 67.2 | 68.5 | 87.5 | 63.2 | 72.4 | 78.5 | 81.3 | 94.8 | 81.7 | 100.0 | 100.0 | 895.1 | 81.64 |
| 3*x* | 52.2 | 42.1 | 55.0 | 47.8 | 51.2 | 40.0 | 56.4 | 73.8 | 81.7 | 85.0 | 89.3 | 674.5 | 61.31 |
| 3*y* | 48.0 | 55.2 | 65.0 | 48.8 | 59.4 | 50.7 | 53.2 | 57.8 | 72.7 | 90.0 | 92.9 | 693.7 | 63.06 |
| 4*x* | 13.6 | 21.1 | 15.0 | 15.6 | 17.6 | 15.4 | 31.3 | 52.6 | 45.4 | 60.0 | 64.3 | 351.9 | 31.99 |
| 4*y* | 54.4 | 47.3 | 65.0 | 52.2 | 56.5 | 60.0 | 72.0 | 79.0 | 59.0 | 80.0 | 85.7 | 711.1 | 64.64 |
| 5*x* | 17.8 | 13.2 | 30.0 | 17.7 | 20.0 | 15.4 | 20.3 | 42.1 | 45.4 | 40.0 | 71.5 | 333.4 | 30.30 |
| 5*y* | 12.0 | 18.4 | 12.5 | 12.2 | 10.0 | 16.1 | 26.5 | 21.0 | 45.4 | 40.0 | 71.5 | 285.6 | 25.96 |
| 6*x* | 2.6 | 5.3 | 7.5 | 2.2 | 2.4 | 2.3 | 10.9 | 23.6 | 9.1 | 40.0 | 46.5 | 152.4 | 13.85 |
| 6*y* | 1.4 | ..... | 5.0 | 4.4 | 1.2 | 5.4 | 7.8 | 15.8 | .... | 30.0 | 57.1 | 128.1 | 11.64 |
| 7*x* | 0.4 | 5.3 | ..... | .... | 3.5 | 3.8 | 9.4 | 13.2 | 13.6 | 35.0 | 42.9 | 131.1 | 11.91 |
| 7*y* | 2.4 | 5.3 | ..... | 1.1 | 8.2 | 3.8 | 12.5 | 13.2 | 4.5 | 35.0 | 53.6 | 139.6 | 12.69 |
| 8*x* | 1.2 | 7.9 | 2.5 | 3.3 | 2.4 | 6.9 | 9.4 | 18.4 | 4.5 | 20.0 | 42.9 | 119.4 | 10.85 |
| 8*y* | 0.6 | ..... | 2.5 | 1.1 | 1.8 | .... | 7.8 | 13.2 | .... | 35.0 | 35.7 | 97.7 | 8.88 |
| 9*x* | ..... | ..... | ..... | .... | ..... | ..... | 3.1 | 5.3 | .... | 15.0 | 14.3 | 37.7 | 3.42 |
| 9*y* | 0.2 | ..... | ..... | .... | ..... | ..... | 3.1 | 2.6 | .... | 10.0 | 14.3 | 30.2 | 2.74 |
| 10*x* | ..... | ..... | ..... | .... | 1.8 | .... | 3.1 | 2.6 | .... | 15.0 | 21.4 | 43.9 | 3.99 |
| 10*y* | ..... | ..... | ..... | .... | ..... | ..... | .... | 10.5 | .... | 10.0 | 7.1 | 27.6 | 2.50 |
| 11*x* | ..... | ..... | ..... | .... | ..... | ..... | 1.6 | ..... | ..... | 10.0 | 7.1 | 18.7 | 1.70 |
| 11*y* | ..... | ..... | ..... | .... | 0.6 | ..... | 1.6 | ..... | ..... | 10.0 | 3.6 | 15.8 | 1.43 |
| 12*x* | ..... | ..... | ..... | ..... | ..... | ..... | 3.1 | ..... | ..... | 10.0 | 3.6 | 16.7 | 1.51 |
| 12*y* | ..... | ..... | ..... | ..... | ..... | ..... | 1.6 | ..... | ..... | 10.0 | ..... | 11.6 | 1.05 |
| 13*x* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 10.0 | ..... | 10.0 | 0.90 |
| 13*y* | ..... | ..... | ..... | ..... | ..... | ..... | 1.6 | ..... | ..... | ..... | ..... | 1.6 | 0.14 |

the adventitious groups and its relation to the age at which deafness occurred.

From Table IX. intercorrelations between each group and every other group were calculated. For this purpose the rank in order of difficulty for the sentences was used, and the correlations calculated by the Spearman formula,

$$R = I - \frac{6\Sigma g}{n^2 - 1}.$$

In all there were 55 correlations, since the adventitious cases acquiring deafness from age seven to fifteen were included in one group. The 55 correlations ranged from $r = .89$ to

$r = .99$. The median of the 55 correlations is .95 and the average deviation from the median is $\pm .017$. These correlations answer very definitely our question as to the relative difficulty of the sentences for the various groups of children. On the whole the difficulty is almost the same for the congenital as it is for any group of the adventitious. Evidently, then, the language development of these different groups proceeds along the same lines.

Correlations between the relative difficulty of the sentences for the hearing children tested by Trabue and the different groups of deaf were also computed in the same manner as the intercorrelations described above. The results are as follows, being in every case a correlation between the hearing children and the group of deaf as noted below:

| Deaf Groups | $r$ |
|---|---|
| Congenital Cases | .95 |
| Unknown " | .91 |
| Acquired? | .92 |
| Before one year of age | .93 |
| Between 1 and 2 years | .92 |
| " 2 " 3 " | .93 |
| " 3 " 4 " | .96 |
| " 4 " 5 " | .97 |
| " 5 " 6 " | .91 |
| " 6 " 7 " | .98 |
| From 7 to 15 years | .99 |
| All deaf and all hearing | .99 |

These uniformly high correlations lead us to the conclusion that the difficulty of the sentences for the deaf is about the same as for the hearing and that, therefore, as far as can be determined from this test, the language development of the deaf proceeds essentially along the same lines as the language development of the hearing. This corroborates previous work by the writers in which the Woodworth and Wells Directions Tests were used.[1]

*Correlation with Substitution Tests.*—In one of the schools tested the Digit-Symbol and Symbol-Digit tests were given at the same time as the Trabue Language Scale and correlations between these tests were computed by the Spearman

[1] Pintner, R. and Paterson, D. G., *op. cit.*

*R* method. The first set of correlations was made between the ranks of the 21 classes in the three tests as determined in each case by the median performance. The coefficients are as follows:

Digit-Symbol and Symbol-Digit with Trabue..... $r = .92$
Digit-Symbol with Trabue..... $r = .93$
Symbol-Digit with Trabue..... $r = .90$
Digit-Symbol with Symbol-Digit..... $r = .96$

These high correlations show that the classes with the high scores in the substitution tests are the best in the language tests, indicating that the tests are good measures for groups of individuals.

The coefficients of correlation between the average rank of pupils in the Digit-Symbol and the Symbol-Digit tests and their ranks in the Trabue Language Scale by years of work are as follows:

| Year of Work | Number of Pupils | *R* | *r* | P. E. |
|---|---|---|---|---|
| 12 | 16 | −.23 | −.35 | ? |
| 10 | 8 | .38 | .56 | ? |
| 9 | 13 | .31 | .47 | ? |
| 8 | 39 | .32 | .48 | .097 |
| 7 | 27 | .31 | .47 | .113 |
| 6 | 39 | .15 | .23 | .110 |
| 5 | 11 | .25 | .38 | .167 |
| 4 | 35 | .19 | .29 | .110 |
| 3 | 25 | .37 | .55 | .101 |
| 2 | 26 | .42 | .61 | .086 |
| | | Average..... | .35 | |

The correlation between individuals at the same stage of instruction is much lower than the correlations of the class medians. In all cases, except one, the coefficients are positive, but the number of cases in some of the groups is very small. Again the P.E. is sometimes very large. On the whole there seems to be some relationship between the abilities tested but not a very close one.

## Summary

1. The Trabue Language Scale has proved to be an admirable test for deaf children. The form of the test is sufficiently familiar to them to make the test easy to give.

Too much does not depend upon comprehension of instructions.

2. On the whole the pupils in the oral classes do better than pupils in the manual classes.

3. The grading of classes in both institutions as far as language work is concerned is poor. There seem to be no definite standards in language work for each class, nor even for each year of work.

4. Division of classes into sections according to ability as measured by a combination of mental and educational tests would increase efficiency in administration and lead to an economy of effort in teaching.

5. Tentative norms of language ability for oral and manual pupils classified according to year of instruction have been determined. These are given in Table III. Norms for all deaf are given in Table IV.

6. The average language ability of the adventitiously deaf is slightly superior to that of the congenitally deaf.

7. The adventitiously deaf who lose their hearing before age four or five do not seem to be superior in language ability to the congenitally deaf.

8. The adventitiously deaf who lose their hearing after age four or five seem to benefit so far as language ability is concerned by reason of having once possessed hearing.

9. The grade abilities of the majority of deaf children fall between −2 and 4. Very few deaf children (6.4 per cent.) reach scores above fourth-grade ability.

10. The language development of the adventitiously and the congenitally deaf proceeds along the same general lines.

11. The language development of hearing and deaf children proceeds in general along the same lines.

# INDIVIDUAL AND SEX DIFFERENCES BROUGHT OUT BY FASTING

BY HOWARD D. MARSH
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During the first three weeks of July, 1915, the writer and his wife undertook to share the hardships of a lengthy fast. Though not of such rigor as endured by numerous predecessors, it was yet of such reality as to produce some distinct experiences; but unfortunately the most interesting and dramatic of these were not fixable by tabulation and graphometry.

## General Routine

During the first of the three weeks the food was reduced gradually from normal to near-nothing; no food was taken during the second week, but from 500 to 750 c.c. of water daily; the food conditions of the first week were exactly reversed the third week. Accurate tests of the various activities were made in the psychological laboratory of the College of the City of New York from 9 A. M. to 1 P. M. daily. In addition, six days of "control" tests were made at odd times but, serving badly in that capacity, have been entirely omitted from treatment here. Observations of general physical welfare and of specific physiological facts, and introspections of general mental status and particular mental tests, were recorded diurnally. Accurate analyses of the blood by a skilled physician[1] and measurements of blood pressure, body temperature, pulse rate, weight changes, and lung capacity were made regularly. Graphic records of the barometric and thermometric conditions throughout the day, and verbal records of visible weather features four times a day, were taken. Our daily program provided also for customary occupations, afternoons and evenings, and was fairly uniform and controlled for the whole period.

[1] Dr. W. H. Boese, district clinical supervisor, Chelsea District of the New York City Health Department, etc.

## The Tests

The series of tests employed covered what may roughly be described as weight and strength, rate and accuracy, sensitivity and passivity, memory span and retentivity. Group A includes (1) weight (stripped), (2) lung capacity (wet spirometer), (3) grip, right and left hands (Narragansett dynamometer, 5 trials each hand) and (4) fatigue (hanging by the arms to the utmost endurance).

Groups B and D include five tests, each measured by the time used and errors made: (1) Association (50 words daily from the Woodworth and Wells series, the qua ity of the associations being estimated by the number of low-grade reactions occurring); (2) naming (the 100 colors and the 100 forms of the W. W. blanks); (3) continuous addition (100 additions daily, W. W. forms); (4) continuous subtraction (100 subtractions daily, W. W. forms); and (5) mental multiplication (ten 2-place problems each day).

Group C includes (1) Touch (single camel's hair, applied 10 times each to top and bottom of tip of nose, positive and negative results being recorded as the hair was or was not sensed); (2) pain (10 threshold values secured from tip of nose by a Verdin algometer); (3) sight (perception of dots, irregularly arranged and ranging from 4 to 9 per card, 30 cards in all, exposed with drop screen); (4) steadiness (tracing a gradually narrowing slit, 25 cm. long, with a metal stylus, contacts with the sides being registered by an electric buzzer, 10 trials with each hand). Taste and smell were tested for two weeks and then dropped, due to the delays and difficulties they entailed; but the results would have proven as interesting as any, had this section of our plan been completed.

Group E includes (1) Immediate memory span (10 minutes allowed for memorizing the 50 words of the association list of the same day); (2) Reproduction (10 minutes allowed for recall of as many words as possible from the preceding day's memory list). The whole series of tests, it will be seen, is fairly comprehensive.

## Method

After the results were secured in terms of quantity (or time) and quality (or mistakes), they were reduced to relative ranks in each test. That is, they were distributed into ten classes giving the most normal scale. By this method the value of the steps between successive ranks varies, of course, from test to test, but in each test remains the same for both sexes, with the necessary change in starting point. It is obvious that a change amounting to one step in rank equals a change of 10 per cent. of the total range of variation displayed in each case.

An example will make this plain. For 20 days in subtraction, the times for the male in seconds were 480, 438, 398, 351, 391, 355, 369, 308, 351, 330, 349, 330, 310, 312, 296, 288, 304, 288, 258, 240; and for the female 500, 498, 431, 416, 366, 357, 329, 330, 344, 310, 285, 300, 285, 296, 292, 298, 252, 250, 255, 220. By inspection and trial it is found that the best interval to use as step is 30 seconds, and the best scale of ranks is produced by beginning for the male at 220 and for the female at 230. The tenth ranks then are '460-up' and '470-up,' respectively. Likewise the errors, ranging from none to six in the one case, and from none to nine in the other, were ranked with the step-value equaling one half.

By this method extreme cases at either end of the series are considerably 'smoothed'; but this may be an advantage rather than a disadvantage, because in a measure it counteracts the influence of uncorrected practice effect. It will be noticed that the lowest score practically is counted zero and the best, and that the rest are related to it in successively *worse* classes up to ten. Therefore in the last table, the results are in grades of *deficiency*, the larger the number the worse the ability. The value of this method of ranking, in the present investigation, lies in its provision for easy comparison of the individual with his own record rather than with an external standard; and of keeping all the results alike in form and hence in a certain sense directly correlatable in the different tests and for the different persons. Estimate of the reliability of the figures shown in terms of the prob-

able error was not made, due to the small number of subjects involved.

TABLE I

AIR AND BLOOD CHANGES

| Week and Sex | Air | | Blood | | | Hemoglobin | Common Cells | | Differential Count | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temp. | Press. | Pulse | Temp. | Press. | | White | Red | P., Per Cent. | L., Per Cent. | M., Per Cent. | E., Per Cent. | B., Per Cent. |
| 1st, M..... | 85.3 | 29.81 | 69.3 | 98.1 | 30 | 90–100 | 7,700 | 5,980,000 | 45.0 | 44.0 | 3.5 | 7.0 | 0.5 |
| F..... | 85.3 | 29.81 | 66.9 | 97.8 | 36 | " " | 7,100 | 5,190,000 | 56.0 | 36.0 | 3.0 | 4.0 | 1.0 |
| 2d, M..... | 82.7 | 29.85 | 71.4 | 97.8 | 14 | " " | 6,200 | 6,650,000 | 67.0 | 26.0 | 5.0 | 2.0 | 0.0 |
| F..... | 82.7 | 29.85 | 61.9 | 97.5 | 18 | " " | 6,460 | 6,440,000 | 48.0 | 41.0 | 9.0 | 1.0 | 1.0 |
| 3d, M..... | 82.3 | 29.95 | 75.6 | 98.4 | 33 | " " | 6,200 | 5,960,000 | 46.5 | 41.0 | 3.5 | 7.5 | 1.5 |
| F..... | 82.3 | 29.95 | 69.3 | 97.7 | 40 | " " | 7,920 | 5,890,000 | 47.8 | 43.9 | 5.5 | 2.5 | 0.3 |

P. = polynuclear; L. = lymphocytes; M. = mononuclear; E. = eosinophiles; B. = basophiles.

## RESULTS

The results of least psychologic interest are given first and condensedly, mainly as collated in Table I. The 'air' figures were secured from a seven-day Tycos baro-thermograph, and show that the average conditions were unusually constant; hence any marked mental influences from this quarter could be ascertained only by careful correlations for each day.

The 'blood' figures are more significant, the fall in pressure for the fasting week being especially pronounced for both sexes. Temperature and pulse also fall, the only sex difference here appearing in the more marked change for the female in heart rate. It is possible that the cellular changes in the blood are most significant, though a glance suffices to show that this is not true of the white and red corpuscles. The latter fact serves to cast doubt on the popularly accepted view that the organism radically is weakened by fasting (a week or ten days)—that the guardian white cells are depleted and thus leave the body exposed to the ravages of bacterial diseases. The writer will not here try to interpret the other cellular changes tabulated, but has included them for the benefit of those who may be interested.

The results of greatest psychologic interest are sum-

marized in Table II., classified roughly under five headings for readier handling, and described briefly as to the outcome of each group. The column marked 'descending' covers results for the first week, the first day excluded due to unavoidable irregularities; the one marked 'fasting' covers the second week and first day of the third week, the latter included because the fasting momentum was unquestionably stronger than the food influence; and the one marked 'ascending' covers the last six days of the period.

By 'fasting loss' is meant that decisive debility was produced by the food deficit; by 'practice loss,' that the anticipated gain due to practice was slowed in rate or not fully realized; by 'practice gain,' that the expectable practice gain was not impeded but appeared in normal degree; and by 'fasting gain,' that decisive ability was produced by the food absence.

Not only does the larger number mean the less ability, but the table is arranged to show first in order, both in the whole table and in its parts, those activities rendered most defective by the fasting.

The first point of interest is the high correlation between the estimated food intake and the changes in weight and strength. The results are practically uniform in trend and are in the direction one would expect.

The next thing of note is that the general trend of the next group, though indicated as "practice loss" is much less decisive than in the preceding case. This partly depends on the fact that the group is mixed, the first three tests involving an important motor element and the last two not. That is, the first three tests tend to follow the preceding group in fasting loss while the last two, more purely mental in character, more nearly simulate the succeeding groups.

In the next group, *C*, the trend is no more distinct. This again is a mixed group but does on the whole show pretty complete practice gain. There are here, as in the other groups, certain sex differences brought out. Sensitivity in the female apparently decreased in touch and sight and increased in pain in the full-fast period, but the reverse was true for the male. Otherwise sex similarity prevails.

## TABLE II

SUMMARIZED RESULTS OF FASTING TESTS

[The larger the number the less the ability]

| Activities Tested | Descending | | Fasting | | Ascending | | Group Names and Results (Estimated) |
|---|---|---|---|---|---|---|---|
| | M. | F. | M. | F. | M. | F. | |
| Food Intake | 4.5 | 4.5 | 8.5 | 8.5 | 3.5 | 3.5 | |
| Weight Loss | 7.3 | 7.2 | 7.9 | 7.0 | 3.9 | 4.0 | |
| Lung Capac | 5.3 | 2.8 | 6.8 | 7.5 | 2.8 | 4.5 | |
| Grip—Right | 2.3 | 5.7 | 6.1 | 6.9 | 6.8 | 5.1 | *A.* Vitality |
| Grip—Left | 4.0 | 5.7 | 7.7 | 5.7 | 7.5 | 5.1 | |
| Fatigue | 7.3 | 4.3 | 8.2 | 8.4 | 1.3 | 3.7 | |
| | 5.2 | 5.1 | 7.3 | 7.1 | 4.5 | 4.5 | Fasting loss |
| Association time | 4.3 | 5.2 | 7.3 | 5.0 | 4.2 | 3.3 | |
| Naming time | 4.1 | 6.0 | 3.6 | 6.7 | 1.8 | 3.6 | |
| Addition time | 6.3 | 6.0 | 6.0 | 6.9 | 4.5 | 2.8 | *B.* Rapidity |
| Subtraction time | 7.5 | 8.7 | 5.4 | 5.1 | 3.4 | 3.3 | |
| Multiplication time | 8.7 | 8.8 | 6.3 | 6.0 | 2.5 | 1.8 | |
| | 6.2 | 6.9 | 5.7 | 5.9 | 3.3 | 3.0 | Practice loss |
| Touch | 6.4 | 5.7 | 5.1 | 6.2 | 4.8 | 3.9 | |
| Pain | 4.0 | 6.5 | 6.0 | 5.0 | 5.5 | 6.8 | |
| Sight | 6.3 | 6.6 | 3.8 | 4.7 | 5.5 | 3.5 | |
| Steadiness time—R | 6.5 | 4.8 | 2.7 | 4.0 | 5.3 | 5.7 | *C.* Passivity |
| " " —L | 4.0 | 4.0 | 5.5 | 4.6 | 5.2 | 6.2 | |
| " space—R | 6.3 | 5.0 | 3.6 | 5.4 | 3.2 | 3.5 | |
| " " —L | 7.3 | 7.3 | 4.6 | 4.4 | 2.7 | 2.5 | |
| | 5.8 | 5.7 | 4.5 | 4.9 | 4.6 | 4.6 | Practice gain |
| Association errors | 6.5 | 5.5 | 7.0 | 7.0 | 4.7 | 6.0 | |
| Naming errors | 5.5 | 6.1 | 4.1 | 1.8 | 2.9 | 3.3 | |
| Addition errors | 4.0 | 6.0 | 2.5 | 4.0 | 3.5 | 1.0 | *D.* Accuracy |
| Subtraction errors | 8.3 | 7.8 | 3.5 | 3.3 | 4.5 | 3.8 | |
| Multiplication errors | 5.3 | 7.2 | 5.1 | 6.0 | 5.7 | 5.5 | |
| | 5.9 | 6.5 | 4.4 | 4.4 | 4.2 | 3.9 | Fasting gain |
| Memorization | 4.0 | 4.7 | 8.1 | 2.7 | 4.8 | 6.5 | *E.* Memory |
| Reproduction | 5.0 | 4.7 | 8.5 | 4.2 | 5.0 | 8.1 | |
| | 4.5 | 4.7 | 8.3 | 3.5 | 4.9 | 7.3 | M., loss, F., gain |
| Total | 5.6 | 5.8 | 5.7 | 5.3 | 4.2 | 4.1 | |

In group *D* it must be admitted that the results are not very homogeneous in their showing or meaning. We have here that part of the given tests most distinctly mental, and while they show most betterment or fasting gain from the food abstinence, they also show most variability and hence

unreliability. As for sex, it may be seen that there is almost perfect agreement in the several traits instead of any differences.

In truth it is only in the last group, *E*, apart from the instances already mentioned, that an undoubted difference appears, the male showing excessive deficiency and the female excessive proficiency from the given ordeal. Even here, of course, it cannot surely be said to be a 'sex' affair, since any two individuals might exhibit the same fact.

Though true that the test-results are technically most interesting, it yet is true that the introspections are informative. I shall mention some things they show of a general nature or about certain days or tests and in relation to shifts in energy, feeling, and intellection.

First, concerning the amount of correlation between the objective and subjective effects. The food was decreasing from the start and quite absent from the 7th to the 15th, yet it may be judged that any effect from its absence would increase after the 7th to a climax, due to new adjustments entailed on the organism; and then would decrease, due to their establishment and to the exhilaration of the approaching end. This climax does come about the 11th, showing in introspections, performances, and weight. Thus the male losses in weight from the 9th to the 12th are nearly nine pounds, from a total of nineteen; the female, five and a half, from a total of fourteen. In the tests, after a starting spurt of high efficiency on the 8th, there was a reactionary drop on the 9th and thence to the 12th, from which time improvement proceeded irregularly to the end.

Introspective records about the date of this turning-point were on the following order. Male: "Heart pounds greatly and more or less constantly, particularly at the pit of the stomach; also beats rapidly and flutters at stair-climbing. Unable to do work afternoon or evening. Great lassitude and discomfort of general nature and in head. Throat dry but no desire for water nor liking of it. Pains in head, eyes, back, legs, especially knees and calves—lying, sitting, or standing. No nausea, but sense of instability in the stomach

—of being easily upset. Feelings of sympathy, joy, reverence, etc., all are reduced in quality—lifeless in fact." Female: "Bath gave no pleasure. Felt like bursting out crying during mental tests and in afternoon. Greatly startled by sudden noises. Experienced hunger for the first time. At night dreamed of fried cucumbers and chopped olives being used as padding around some mechanical apparatus. To undertake anything seems a great effort and I can't speed up beyond a jog trot. My emotions have returned (on the 12th) after several days of torpor." Though physical fatigue and inertia continue after the 13th, mental conditions begin to mend, as already suggested.

The question of 'how it feels to fast' is of main concern to most persons who have not indulged in severe dietary regimens. While the characteristic hunger sensations were experienced at meal times on several days, even occasionally accompanied by belchings, nausea and vomiting, especially in the case of the female, yet the discomfort on this account is not as gigantic as it looms in imagination. No doubt it would be truest to say that it is masked by the prevailing somatic state of ill-being or odd-being, relativity being so great a factor in all experience. The complexity and intensity of this state would appear were our introspective terms fully listed here, instead of merely sampled in the preceding paragraph.

Concerning the correlation of specific introspected feelings and actual test results, our records show very high agreement at times and equally low at others. Of 100 judgments recorded by the male subject, concerning his feelings of progress and accuracy in particular tests, 60 showed positive correlation and 40 negative. For the female the matter is more ambiguous and quite undecipherable mathematically, as this typical quotation will show: "I feel as though I am very slow in doing my tests even though they are shorter in time than usual. I have a feeling of impatience as though one part of me were having to wait for another part; and it is almost as though the impatient part were saying 'Stop trying and let me do your work; I can do it faster and better than you': and when I do stop trying, this unseen part puts

down the answers with such great ease and speed that I marvel at its achievements." This dual-personality experience was present a number of times and the side of it which felt like 'doing things' often produced results just the opposite. In fact the correlation between the work as appraised subjectively and as measured objectively seems for the female about as negative as for the male it was positive. But the distribution of judgments in both cases would be rather close to that of 'chance.'

## Conclusion

The immediate effects of the fast as shown by the tests indicate a depletion of vitality and strength commensurate with the reduction of food intake; and to some extent a slowing-down in the speed of activities, more for the motor than the mental. The sensory and passive sides of the self are not greatly affected, generally speaking, but sexually show male sensitivity for pain and perceptivity for dots increased, and for touch decreased; while for the female the reverse is true. Some improvement for both sexes is shown in mental clearness and accuracy, though not decisively; and a most pronounced effect upon memory, disadvantageous for the masculine subject and advantageous for the feminine. The feelings, unusually acute for several days and then unusually apathetic for a time, were on the whole ambiguous indices of the grades of objective performance, less so for the male than the female. Had the efforts required by the tests been more protracted and exacting in character probably the subjective-objective correlation would have been higher.

The ultimate effects of fasting, upon both health and ability, it is most desirable to know. Doctors often do not promise radical health changes without months of definite dietary changes. Ancient reports of fasts are bad scientifically through lack of proper control and measurement. Modern researches cover these points better but are bad practically from failure to shed light on an after-period. The present experiment fails similarly, due to a shift from laboratory to camping life concurrent with its completion. Instead of remaining a negligible part these remoter effects should be made the main goal of future fasting studies.

# THE HUMAN SALIVARY REFLEX AND ITS USE IN PSYCHOLOGY

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The experiments of Pawlow and his students upon the conditioned salivary reflex have provided a method of investigation, which already has proved useful in the study of the sensory physiology of animals, and which promises to be even more valuable in revealing fundamental factors of habit formation and of central inhibition and reinforcement. Pawlow's technique is restricted rather narrowly, however, to larger mammals which combine a relatively abundant salivary flow with the possibility of operative methods; practically to dogs among laboratory animals. The restriction is not without advantages, since it tends to concentrate the work upon a single organism, but an extension of the method to man also seems desirable, as there is little agreement in the results obtained by the use of the conditioned salivary reflex and of motor habits.

Zeljony ('07) and Johnson ('14) have obtained quite conflicting results in studies of audition by the use of the two methods. In the field of vision, too, there are similar discrepancies which may or may not be due to the fact that the Russian investigators have not used well-controlled stimuli. A revision of the work with the possibility of a difference in the thresholds of muscular and glandular reactions is desirable. This can be carried out to best advantage with human subjects.

Pawlow has largely refrained from anthropomorphic interpretation of his results but some of his followers are not free from this error. Dontchef-Dezeuze ('14) especially, has given an elaborate and wholly unjustified interpretation of the process of association in conditioned secretion in terms of images and affective elements. In the present stage of

objective psychology her assumptions can be tested only by experiments on man. The whole problem of the relation of emotional reactions to the conditioned reflex is untouched and the stimuli exciting these can be most easily controlled with human subjects.

Finally, the increasing emphasis which glandular activity is receiving in physiological psychology calls insistently for a fuller understanding of the conditions governing secretion than we have at present. While the salivary glands are perhaps the least important of all the glands for psychology they offer the only opportunity for the direct study of the relation of stimulus and glandular reaction in the human subject. The remaining digestive glands, the lachrymals, the reproductive and ductless glands are too well protected for direct study and the sebaceous glands offer great difficulty because of their scant secretion. To what extent conclusions drawn from the salivary glands can be applied to other glandular reactions can probably be determined only by operative experiments on animals.

A number of studies of the human salivary reflex have appeared, but for the most part they deal with detached observations and no general summary of the work has been made. Such a summary seems desirable for orientation in further experiments and in the following pages an attempt has been made to review the more important papers dealing with different aspects of the reflex in man. The literature upon the salivary reflex in other mammals is very extensive, including more than two hundred studies, and it has not been possible to do more than mention the general results of this work as indicating points which must be considered in any experiments upon the conditioned salivary reflex in man. A number of papers dealing with variations in the chemical composition of the human saliva have been cited only where they indicate a differential reaction to stimulation. In general only such material has been included as seems to bear directly upon the reflex mechanism of secretion. In summarizing the literature it has seemed best to consider it in topical rather than in historical form, since the latter would necessarily involve much repetition.

Practically all existing studies of human salivary secretion have been confined to the parotid gland, which is most easily accessible. In animals, on the other hand, the submaxillary has been studied most extensively. The innervation of the two glands is, however, essentially the same in its general features, although derived from different nerve roots, and there is no evidence for any fundamental difference in their mechanism of reaction. They show differences in excitability to specific stimuli but their reflexes are alike in their general capacity for inhibition and modification by training.

## Methods of Obtaining the Secretion

There has always been a considerable difficulty in isolating the secretion of the single glands, which has militated against long-continued studies of salivation in man. Three methods of obtaining the secretion have been used. Lassaigne and Tuczek ('76) had their subjects chew dry food and measured the increase of this in weight, thus obtaining the total secretion. The range of applicability of this method is obviously limited. Eckhard ('63) and Oehl ('64) have worked out a method of using a canula inserted into the ducts of the larger glands. According to Ordenstein ('60) the method is not accurate since leakage of the secretion around the canula may occur and it is exceedingly difficult to keep the canula in place. The technique of inserting the canula is somewhat difficult also, and Babkin ('14) considers that its presence in the duct leads to a continuous reflex excitation of the gland. The most thorough studies have been made upon subjects in whom a fistula of one of the salivary ducts has been established accidentally. Such cases, however, are rare, and have thus far been found to involve only Stenson's duct. The writer has devised a simple drainage tube to be attached over the mouth of Stenson's or of Wharton's duct, which is free from most of the objectionable features of the canula.[1]

## Secretion of the Glands in the Absence of Stimulation

The existing data upon the normal rate of secretion of

[1] This apparatus has been figured by Watson ('16) and will be described in a paper to appear later in the *Journal of Experimental Psychology*.

the parotid gland in the absence of extero-stimulation shows a great amount of variation in the glandular activity of different individuals. Zebrowski ('05), using subjects with fistulas of Stenson's ducts, and Brunacci ('10) using a canula to drain off the secretion, find little or no glandular activity during rest. Butler-Stoney ('73) found a little secretion in a subject with a fistula but gave his data in terms of the time required to fill Stenson's duct so that his results are not comparable with those of others. The more accurate records given by other investigators are summarized in Table I. The results, with the exception of those of Küss, are based upon observations extending over several hours during which the secretion remained fairly uniform. The secretion found by Butler-Stoney, Mitscherlich, and Küss in subjects with fistulas indicates that the secretion obtained by the use of the canula is not, as Babkin ('14) thinks, wholly the result of excitation by the canula, but that there is a constant slight secretion of the parotid gland without extero-stimulation. This, however, may be reflex in nature, since there is probably a constant stimulation of the mucosa of the digestive tract.

TABLE I

SUMMARY OF THE EXISTING DATA UPON THE RATE OF SALIVARY SECRETION IN MAN, IN THE ABSENCE OF EXTERO-STIMULATION

| Subject | | Secretion Grs. per Hour | Conditions of Stimulation | Investigator | Method of Collecting Secretion |
|---|---|---|---|---|---|
| Sex | Age | | | | |
| Parotid gland | | | | | |
| ♂ | 40 | 0.08 | Subject sleeping. | Mitscherlich ('33).. | Fistula |
| | | 0.53 | Reading quietly. | | |
| ♂ | 17 | 11.80 | Subject quiet: Vegetable diet. | | |
| ♂ | 18 | 1.00 | Mixed diet.... | Ordenstein ('60)... | Canula |
| ♂ | ? | 4.50 | Meat diet..... | | |
| ♂ | 49 | 1.10 | Vegetable diet. | | |
| ♂ | 60 | 0.80 | Subject quiet..... | Küss ('99)..... | Fistula |
| ♂? | ? | 1.70 | Subject quiet.... | Oehl ('64)..... | Canula |
| ♂? | ? | 2.20 | " " .... | | |
| ♂? | ? | 1.66 | " " .... | | |
| Submaxillary gland | | | | | |
| ♂? | ? | 7.12 | Subject quiet.... | Oehl ('64)..... | Canula |
| ♂? | ? | 6.00 | " " .... | | |

Ordenstein ('60) alone has observed the rate of secretion in a human subject for a twenty-four-hour period and the

individual with whom he worked, a poorly nourished boy, was probably, as Buff ('88) suggests, pathological. Little variation appeared in the rate of secretion of this subject during the twenty-four hours except after food was taken, when an increase in the rate of secretion appeared.

Mitscherlich ('33) studied a man, forty years of age, with a fistula of the left Stenson's duct. He found that during sleep the gland produced about 0.09 c.c. of saliva per hour; during quiet reading with movements of the mouth from 0.41 to 0.53 c.c. per hour; during meals the quantity of secretion varied from 0.8 to 2.0 c.c. per minute. For ten hours during a fast when the subject was unusually quiet the saliva was collected constantly but not enough was obtained for measurement. In this case the amount of secretion seems to be proportional to the degree of activity of the subject.

In the observations of Ordenstein there was no correlation between the amount of secretion and the diet of the subjects studied. Tuczek found a relation between the total quantity of saliva secreted and the age and sex of his subjects, women and children giving less secretion than men. Since different individuals may vary in the size of the food particles which excite the swallowing reflex and in the relative efficiency of gustatory stimuli to excite secretion, the method of Tuczek, which required the subject to chew dry food until a bolus was formed ready for swallowing, is not reliable as a measure of individual difference.

The other human salivary glands have been studied scarcely at all. Eckhard ('63) described a method of obtaining the secretion of the submaxillary by inserting a canula into Wharton's duct and made some observations upon its chemical properties, but did not study the reflex excitability of the gland. Oehl ('64) determined the rate of secretion of the submaxillary gland in two normal human subjects to be 7.12 and 6.00 grams per hour. He also described a method of obtaining the secretion of the sublingual gland but made only a few observations on the chemical composition of the saliva obtained.

## The Unconditioned Salivary Reflex

Reflex secretion is excited most readily, perhaps exclusively, by stimulation of the oral mucosa. Popielski ('09) criticizes the work of several investigators because they failed to control the temperature of gustatory stimuli, but offers no evidence to show that the temperature of food is an adequate stimulus to secretory activity. Brunacci ('10) tested the stimulating effect of water at temperatures ranging from 0 to 80 degrees C. applied to the oral mucosa and found that temperatures above 60 and below 15 degrees have a slight excitatory effect, calling out from one to three drops of secretion for each cubic centimeter of water placed in the mouth. He holds that the excitation here is mediated by the pain receptors rather than by those for temperature.

Mechanical stimulation of the mucosa of the mouth is believed by most investigators to be an effective stimulus to salivary secretion. Some evidence from animals seems to support this view, but it is not altogether conclusive. Heymann ('04) is cited by Babkin as having obtained secretion by mechanical stimulation of the tongue of the dog but so much of his data as is available shows very little excitability to mechanical stimulation uncombined with gustatory, or with chewing movements. Popielski obtained abundant secretion when he placed sand in the mouth of a dog and considered this reaction to be the result of the penetration of fine particles to the bases of the papillæ, where mechanical stimulation should be most effective.[1]

In man the evidence for excitation by tactile stimulation of the salivary glands is derived wholly from observations upon the effects of chewing. Zebrowski, in particular, has ascribed the abundant secretion obtained by chewing tasteless objects to tactile stimulation and Brunacci also has failed to distinguish between the mechanical and other stimuli involved in chewing. Ordenstein has shown secretory

[1] From experiments with human subjects I am inclined to think that the stimulus from sand is complex, involving primarily a reflex contraction of the throat with slight nausea which is an effective salivating agent in the absence of mechanical stimulation. A small amount of sand excites a much more abundant secretion than any amount of stimulation of the tongue and hard palate with a stiff-bristled brush.

reactions to stimulation of the walls of Stenson's duct but no other studies of the tactile excitability of the gland have been made.

The results obtained by various workers upon the effects of chewing are quite conflicting. Bernard ('55) states that, except in ruminants, the parotid functions only during chewing. Colin ('52) believed that chewing is an effective stimulus only because it reduces the size of the food particles and so allows a more ready stimulation of taste. Wulfson ('00) denies that chewing has any effect upon secretion. These results were obtained with animals, chiefly with the dog and horse. Küss gives evidence to show that in his subject chewing movements with empty mouth increased the rate of secretion from 0.8 to 20.0 c.c. per hour. Zebrowski states that chewing movements with empty mouth have no effect upon secretion, that chewing tasteless wax has little effect, and that bread is a much more effective stimulus if chewed than if held quietly in the mouth, thus supporting the view of Colin. Brunacci ('10) obtained from 7 to 15 drops of saliva per minute by chewing tasteless rubber and ascribes this, without further attempt at analysis, to mechanical stimulation.

The lack of agreement in these observations suggests that there must be a great deal of individual variation in the excitatory effects of chewing. My own experiments indicate that the reaction is fully as complex as many conditioned secretory reflexes and depends to a large extent upon previous visual and cutaneous stimuli.

Zebrowski found that chewing upon one side stimulated the gland of that side more than the other, thus confirming an earlier observation of Colin on the horse.

Swallowing movements have been found effective stimuli by Brunacci ('10). His subjects swallowed many times in rapid succession to produce secretion and the possible excitatory effects of movements of the tongue, etc., were not excluded.

No very extensive studies of the glandular reactions in man to gustatory stimuli have been recorded. Mitscherlich

('33) found a greater secretion in reaction to tasteful than to tasteless foods but could not carry out experiments with his subject. Tuczek gives data upon the amount of secretion obtained in chewing a large variety of foods, both moist and thoroughly dried, finding that secretion varies inversely as the water-content of the food and is influenced by the factor of taste. Zebrowski has made the most extensive study of the relation of the quantity of secretion to the amount of the stimulating chemical substance. In a large number of tests in which his subjects chewed and swallowed measured quantities of dry bread he found that the amounts of secretion were almostly exactly proportional to the square roots of the weights of the bread taken, and from these observations he deduced the law that the quantity of secretion is directly proportional to the square root of the intensity of stimulation. This does not agree with the observations of Popielski with the dog. He found in a few tests with water and sand that the quantity of secretion is directly proportional to the absolute quantity of the stimulating substance. Brunacci has pointed out the complexity of the stimuli involved in Zebrowski's experiment and considers that his law holds only for the particular case.

In all studies of the relation of the intensities of secretory reaction and stimulus very crude methods of applying stimulation have been used and it is not possible to say that the variations in the quantity of secretion resulted wholly from changes in the intensity of stimulation. The excitatory effect of a given stimulus varies with the area of the tongue and palate stimulated, with the duration of stimulation, with the rate of dilution of the stimulating substance with saliva, and probably with other variables besides the concentration of the stimulating substance. Thus Zebrowski's experiments are complicated by the different times required to reduce the different quantities of bread to a bolus ready for swallowing and by the rate of solution in the saliva of the gustatory substances from different quantities of bread.

Brunacci has shown that the secretion of the human parotid increases with increasing concentration of acid stimulus

solutions but has made observations with only a few concentrations. Little more than this has been discovered in the studies with animals.

In the experiments of Popielski it was shown that the secretion induced by iso-percentage solutions of acids is closely proportional to the molecular weights of the acids; in other words, that the excitatory effect of an acid stimulus is proportional to the degree of ionization of the acid. Experiments with other gustatory stimuli have not given any results capable of generalization beyond the facts that all gustatory stimuli excite secretion and each excites a specific quantitative reaction.

In this connection the qualitative changes in secretion after stimulation with different taste substances should be mentioned. This has been studied by Zebrowski and by Brunacci. The former found variations in the organic content of the parotid saliva ranging from an average of 0.10 per cent. with saturated salt solution to 1.48 per cent. with coagulated egg albumin. The alkalinity of the secretion was found to vary also, being greatest after stimulation with acid. The latter has made similar observations with a more extensive analysis of the physical and chemical properties of the secretion, including density, osmotic pressure, conductivity, and digestive power. There are specific qualitative reactions to gustatory stimuli.

In experiments with dogs a close correlation between the percentages of solid substances in the secretion elicited by gustatory stimulation with different foods and the conditioned secretion to the sight and smell of the same foods has been demonstrated by Sellheim ('04). Similar observations have not been made on man.

The excitability of the salivary glands in man to stimuli other than those applied to the mucosa of the mouth has not been demonstrated. The fact that during hunger the sight, smell, or thought of food excites secretion has been mentioned frequently but in attempts to obtain this secretion under conditions where it could be measured it has not appeared. There is good evidence that in the dog the secretion

following the sight or smell of food is an acquired reflex. Snarski ('01) found no reflex secretion in this animal to the sight of food. Zitowitsch ('11) fed young dogs exclusively on milk for half a year and found, at the end of this time, that secretion was excited by the sight and smell of only milk or milk products (cheese, etc.). Reflex secretion to gustatory stimulation by other foods appeared, however. Finally, Zeljony ('11–'12) found that ablation of the cortex in dogs abolished the salivary reflex to all stimuli except those applied directly to the oral mucosa. From these experiments it seems probable that in man also the reflex secretion at the sight and smell of foods is acquired and that the laboratory tests have not fulfilled all the conditions necessary for the appearance of the reflex.

A few other direct salivary reflexes have been described, but their position as unconditioned reflexes is doubtful. Aschenbrandt ('81) found that irritation of the cornea of the dog resulted in heightened salivary secretion and attempted to trace out a direct reflex path from the eye to the salivary glands. Buff ('88), who repeated his experiments, was unable to get any evidence of such a reflex and thought that the secretion observed by Aschenbrandt was due to the struggles of the animals. Oehl ('64) likewise failed to obtain any such reflex by stimulating the human cornea.

Jänicke ('78) advanced evidence for a reflex from stimulation of the mucosa of the stomach by chemicals introduced through a fistula. This was denied by Braun and by Buff, whose experiments showed no increase in secretion after such stimulation. Ordenstein's data indicate an increase in secretion after his subject took food but the after effects of the gustatory stimulation in eating were not controlled. The existence of a direct reflex from the stomach is not established.

Parfenow ('05–'06) showed that in the dog the secretion of saliva is increased when the temperature of the surrounding air is raised above 21 degrees R. The reflex nature of this secretion is established only indirectly by the fact that the body temperature of the animals did not rise during the experiments.

In explanation of the results of Aschenbrandt and of Jänicke, Buff assumed that active movements on the part of the animal lead to an increase in secretion, but he gave no experimental evidence in support of this opinion. His view is supported, however, by the observation of Tangl ('96) that horses which have had violent exercise show more fluid in the stomach than those which have remained quiet.

Colin ('54) states that salivation is increased during sexual excitement in animals and von Bechterew that light stimulation of the genitals increases the rate of secretion in the dog. Neither author, however, reports his observations in detail and in view of certain observations of my own upon the inhibition of the swallowing reflex during sexual excitement I am inclined to believe that the seeming increase in secretion observed by these authors was due merely to the retention of the normal secretion in the mouth.

The increase in secretion described in many types of paralysis needs further investigation. Drooling of saliva has been taken as an indication of this increase but no actual measurements of the flow have been made.

## Inhibition of Secretion

Pawlow ('78) was the first to report an inhibition of the normal salivary secretion. He found that when he opened the body cavity of the dog and drew out the folds of the intestine there was a reduction in salivary secretion which persisted so long as the protopathic stimulation was continued. He considered that this inhibition was the result of the excitation of specific reflex paths from the region stimulated. Fubini ('94) obtained a similar inhibition of secretion when he violently stimulated the skin or the sciatic nerve of the dog. His observations suggest that there may be, perhaps, an inhibition from any protopathic stimulus and that Pawlow was not dealing with a restricted reflex.[1]

Brunacci and DeSanctis ('14) have reported experiments to show that intense mental application (translation from a

[1] My own observations on man have shown inhibition of salivary secretion following protopathic stimulation of the skin.

foreign language, computation, etc.) partially inhibits secretion of the parotid. Their method was to place a small quantity of dilute acid in the subject's mouth at the beginning of each successive minute during observation and record the secretion obtained as the result of this stimulation, applied while the subject was at rest and while engaged in mental work. A serious defect in this technique is the fact that the reaction to a gustatory stimulus varies with the area of the mouth stimulated and this is dependent largely upon movements of the tongue. When the subject is distracted the movements of the tongue are largely inhibited and the result is a lesser degree of stimulation. In my own experiments where this method was used an apparent inhibition of secretion sometimes disappeared with careful attention to the distribution of the stimulating substance. I can not find that Brunacci and DeSanctis have controlled this source of error.

A few cases of hysterical inhibition of secretion have been reported (Hadden, '89). In the patients described a complete absence of all salivary secretion appeared and persisted for months. Secretion could be obtained at first by the use of pilocarpin but the effect of the drug grew progressively less. Spontaneous recovery has been observed, but the condition has not been studied adequately.

## Summary

These rather unrelated studies include practically all the material bearing upon the direct reflex in man. They show excitability of the glands to a large variety of stimuli applied to the oral mucosa but disagree in many important details. The chief unconditioned salivary reflexes are summarized in Table II. It will be seen from this that mechanical and gustatory stimuli and the withdrawal of water from the oral mucosa are the only excitants of salivary secretion, investigated by more than one man, concerning which there is agreement. With respect to gustatory stimuli there are no complete studies of the quantitative reactions to different qualities and intensities of stimulation yet the few observa-

## TABLE II

STIMULI EXCITING REFLEX SECRETION OF THE SALIVARY GLANDS IN MAN AND ANIMALS

+, Reflex present: −, Reflex absent

| Stimulus | Reaction in Man | Investigator | Reaction in Animals | Investigator |
|---|---|---|---|---|
| Oral: | | | | |
| Gustatory | + | All | + | All |
| Thermal | − | Brunacci | + | Heymann |
| Tactile | + | Zebrowski; Brunacci | + | Heymann |
| Withdrawal of water | + | Tuczek; Zebrowski | + | Popielski |
| Protopathic | | | + | Heymann |
| Organic: | | | | |
| Chewing | + | Küss | − | Zeljony |
| | − | Zebrowski | | |
| Swallowing | + | Brunacci | | |
| From mucosa of stomach | + | Ordenstein | + | Jänicke |
| | | | − | Braun; Buff |
| Corneal | − | Oehl | + | Aschenbrandt |
| | | | − | Buff |
| Cutaneous, thermal | | | + | Parfenow |
| Sexual | | | + | Colin; Bechterew |
| Inhibitory stimuli: | | | | |
| Visceral | | | + | Pawlow |
| | | | − | Buff |
| Protopathic | | | + | Fubini |
| Psychic | + | Brunacci and DeSanctis | | |

tions that have been made indicate a specific reaction for each taste substance which, with the introduction of accurate methods of giving the stimuli, will probably prove to be very accurately adjusted.

The existence of reflexes from other parts of the body than the mouth, while not absolutely proved for any particular case, is yet sufficiently supported by the existing evidence to promise valuable returns to future investigation.

### CONDITIONED REFLEXES IN MAN

Three attempts to investigate the conditioned salivary reflexes in man have been made. Zebrowski found that his subjects showed no increase in secretion at the thought or even at the smell and sight of food. Brunacci also obtained no evidence for conditioned reflexes to food in man. This, if I interpret him correctly, he ascribes to the fact that man analyzes the experimental situation and can not be deceived

into expecting food, as the dog is under similar conditions. Stated in objective terms this probably means nothing more than that the stimuli to conditioned secretion in man are complex situations which were not duplicated under laboratory conditions.[1] Gley and Mendelssohn ('15) were able to make a few tests in a patient with a fistula of Stenson's duct. They obtained only a slight secretion at the sight of food and no significant secretion at the thought of it. They then attempted to establish a conditioned secretion to sound and light. A series of notes was sounded on a flute, or a bright light was flashed in the eyes of the subject, and at the same time a small piece of chocolate was placed in his mouth. About 40 such stimulations were given with each (light and sound), but no conditioned reflex to either was established. The authors point out that their experiments were not continued long enough to justify the conclusion that conditioned salivary reflexes can not be established in man[2] but do indicate that such reflexes are difficult to form. Their failure is ascribed in part to the stimuli chosen but what they consider the chief difficulty is stated thus: "It seems difficult to us to conceive of the production of 'conditioned reflexes' without the intervention of psychic elements, phenomena of memory and association, images, perhaps even simple judgments, etc.; it is probable that in so complex a reaction the individuality of the subject, especially in the human species, may play a great rôle."

## Discussion

The interest of psychologists has been directed to the salivary reflex chiefly as an index to the sensory physiology of animals. For this it is probably less valuable than the conditioned motor reflex since its use is attended by many technical difficulties (Watson, '16). For an analysis of the mechanism of learning, on the other hand, the study of the

[1] I have had no difficulty in obtaining a reflex secretion in human subjects at the sight of food when the subject was hungry enough to be interested and was under conditions where he had previously obtained food.

[2] In experiments with dogs 70 or more stimulations may be required before the conditioned secretion appears.

conditioned salivary reflex is of the greatest importance.[1] The method of producing it is quite simple, consisting essentially of the simultaneous application of some indifferent stimulus, such as the sound of a bell, with one which excites a direct salivary reflex, such as a gustatory stimulus. The appearance of salivary secretion following the application of the originally indifferent stimulus forms an almost ideal example of an associational as contrasted with a trial-and-error method of learning.

It presents three advantages over other methods of studying the mechanism of learning. In the first place the conditions may be so arranged that only two stimuli and, presumably, one reaction are involved. In studies of the effects of the intensity of the stimuli and of the distribution of practice upon the rate of learning this simplification of the problem is of considerable importance, but its greatest usefulness should be for studies of the temporal relations between the primary and the associated stimulus necessary for the formation of the association.

The fact that a single reaction is involved is also an advantage. The associated reaction either does, or does not, occur and there is no question of the elimination of errors or simplification of reaction. This is true also of verbal association, but in the latter case there already exists an elaborate system of word habits whose influence on experimental studies has not yet been determined. (Even nonsense-syllables occasionally touch an emotional complex.)

Finally the relative independence of the salivary reflex from the complex conditions of reinforcement and inhibition which affect the activity of striped muscles bears directly upon those theories which ascribe an important rôle to consciousness in learning. Neither 'voluntary' nor 'purposeful' secretion is possible and, normally, the subject is unable to tell whether or not he has given a salivary reflex in response to a given stimulus, yet the course of the formation of a conditioned reflex is typically that of habit-formation.

[1] Conditioned motor reflexes may be of exactly the same character but their relation to voluntary activities is not yet established.

Studies of the formation of conditioned reflexes in dogs have already revealed a number of other phenomena of almost equal significance. In particular, the lack of differentiation of the conditioned reflex when it is first established, its total disappearance with continued excitation without reinforcement by the unconditioned stimulus, and the possibility of using a thoroughly established conditioned reflex as a foundation for the formation of others are characteristics of association which have received little attention except in these studies.[1] A fairly complete account of the formation of conditioned reflexes is given by von Bechterew in his 'Objective Psychology.'

Modification of salivary secretion during emotional disturbance is a matter of common experience (Cannon, '15, cites the Chinese rice test as an illustration of the inhibition of salivary secretion by fear) but no controlled experiments have been made. A point in this connection seems to be of considerable importance for a reflex theory of the emotions. The majority of subjects are unable to tell whether or not a given stimulus has excited salivary secretion in them[2] which indicates that there are no afferent impulses from the gland of sufficient intensity to excite activity of the speech mechanism. Wm. James speaks of the secretion of tears as an involuntary process, the sensations from which may contribute to the emotional complex of sorrow. If the afferent connections of the lachrymal and other glands are like that of the salivary, any direct contribution of glandular activity to emotional complexes must be sought by objective means, since the afferent stimuli will be below the threshold of the language mechanism.

It has never been possible to obtain an accurate measure of the intensity of reaction in studies of the movements of man and of the intact animal, owing to the spread of nerve-

[1] The two latter phenomena furnish, I believe, the clue to the nature and rôle of interest and motive in complex human learning. A loss of interest clearly corresponds to the fatigue of the conditioned reflex, which seems to be the more fundamental of the two.

[2] Two exceptions to this rule complain of severe pain in the gland after an acid stimulus. Both have a history of infection which probably resulted in a constriction of some of the smaller ducts.

impulses with intense stimuli and the resulting diversity of activity. Hence, studies of the relation of the intensity of the stimulus to the organism have been restricted almost wholly to sensory physiology in the elaboration of the laws of psycho-physics and the possibility of interpreting these laws in terms of motor response has received very little attention. The ease with which the quantity of secretion of the salivary glands may be measured, the consistency of their reactions, and their relative freedom from inhibition make them especially promising for studies of this sort.

What additional facts will be revealed in the study of conditional reflexes in man can not be predicted. Even if nothing more comes of it than a verification for man of the observations already made for other animals, the interest of psychology in the subject will have been justified.

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# INTUITION

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If one may trust for scientific purposes one's general experience at first hand, and the common and wide experience of numerous life-observers who write fiction, at second hand, there is now no acceptable reason for denying that this popular concept, intuition, is a live one and a real, worthy therefore of at least brief scientific discussion. Some bolder psychologists would go further, and maintain that obviously intuition is more characteristically feminine than masculine. In the light of certain modern behavioristic trends in psychology and of our new more exact knowledge of the 'subconscious,' intuition takes on a new and an important interest.

It has been pointed out that there are in the present mind of philosophy at least three more or less distinct concepts labelled 'intuition.' First (now for the most part 'of only historic interest') is the intuition of unlearned primary truth, the familiar 'immediate knowledge of first and fundamental truths.' I need only point out as we pass that this 'immediacy' of knowledge of Reid was due solely to the blank darkness of subsensory associations, especially inferences, which only now, with the mind as it really is coming slowly into its own, we are beginning to explain and to understand. As a pretender at least to 'common sense,' we may be very sure that Thomas Reid, keen analyst of his day's advances, would be today eager to accept the modern attitude toward these hidden reasoning powers of mind that have 'attained.'

A second concept of intuition is that pragmatic notion used much in common thought and speech which we here shall try, superficially at least, to analyze and then to orient: insight into foresight.

A third use of the term is the partly metaphysical usage of

Bergson—'instinct become disinterested,' discursive thought by which, although intending it at first only for its explanation, we shall finally *control* our behavior. Here again we see the hint of things that are to be better understood forthwith, that keen appreciation of the essential identity of soul and behavior; of perception, recognition, intuition, and bodily movement of some mode; which indicates as well at least as anything else the prophetic wisdom of the James-Bergson attitude:—heaven not only 'the vision of fulfilled desire' but of the bodily processes of reaching it. So far as space and time are concerned, of course Bergson's 'intuition' goes further and suggests logical subtleties in imagination at least quite too far away from the mortal behavior of the average student to come within our present scope, interesting metaphysically as it is. But so far as Bergson's notion of perception is concerned, basis of reasoning, yet somatic to its core, intuition as known, for example, to the average 'lady reporter' gets not a little clarification. Recognition and even perception means more than psychomotor adaptation,—and that more is a germ of our intuition; appreciation no longer conscious of its afferent neurility at all, 'instinct become disinterested' indeed.

Nor is a fourth use of the term intuition, seldom heard and more or less inaccurate, any further away from the basal sense-root of *insight*, namely as insight in regard to the future, especially an evil future: presentiment, foreboding. Its occasional use in this special sense suggests the generality of the term's employment among the people, but otherwise for us has no interest now.

Thus we may note that intuition means in fact, as it does in etymology, practically the same as *insight*, or at least *is* insight—insight, namely, into situations ejective, objective, or sometimes subjective, and of course into any combination of the three. I am content to rest with the simple figurative concept *insight* as a working definition of intuition until analysis of the elemental processes involved shall have extended the connotation of the process and so made our 'insight' more satisfying as a definition. Epigrammatically,

one might say it was insight into foresight. One may say then that *intuition is immediate knowledge of or insight into ejective, objective, and subjective processes or situations*, this insight involving at least the four following kinds of psychophysical event.

In the briefest possible terms, too concise to be thoroughly scientific, it seems that intuition perhaps has as its inherent character a fourfold nature: I, a delicate and sometimes ill-realized *affect* anent the intuited situation. II, a more or less accurate *process of comparison and inference* usually not at all consciously appreciated. III, *comprehension* of the situation, often with much acuteness and with far-reaching wisdom. And, IV, an effective *instinct to trust* the impression thus presented in the mind, the instinct in the adult being already long habitual.

In such a formulation we may distinguish a number of named mental processes obvious or closely and certainly implied and implicated beneath a figurative surface: *A*, keen perception, perhaps by all the sesnses simultaneously, implying sensitive receptors, and afferent centers and adequate sense-training inherited or personally acquired. *B*, delicate emotional mechanism with little starting-inertia and a minimum of muscular or glandular gross action, the 'soma' of the affect involved being largely neural,—as is the case with all long-inhibited feelings. *C*, awareness of the emotional aroma, however subtle, and *D*, appreciation, more or less consciously, that it has significance. *E*, an attempt to understand this significance; which promptly leads to *F*, a process of comparison, *G*, a judgment coming from the comparison (based on the nature of likeness and unlikeness),[1] and *H*, a more or less unconscious mysterious human mental process that we term inference. *I*, an integration of the affect and the reasoning process into, *J*, a conscious tendency to the understanding of the factors of the situation, however

[1] An experimental study of likeness and unlikeness was reported by the writer in the *Journal of Philosophy, Psychology, and Scientific Methods*, 1910, 7, 57–64. Its evidence speaks for a dynamic correlate of judgments of this kind and one more or less appreciable.

novel or complex so long as rational (including caprice) and not materialistically fortuitous; here life-experience comes in to aid the intuitive process greatly and we find the penetrating 'woman of the world' of fiction. *K*, the product of this complex fabrication (in the etymological sense!), however new or unfamiliar, is unconsciously believed in as wisdom from the soul's deeps, an instinct which involves, *L*, a feeling of self-confidence. This leads in its turn to *M*, a conscious and most gratifying *product*, and the woman knows and understands something which is of *use* to her, and often to others, in the conduct of a difficult Life, something which may protect her or hers, something oftentimes which makes her naked momentary intuition of more real worth than the male's most labored and extended mental toil of thought.

Such an 'analysis' as this of a mental action into thirteen elementary parts is of course purely artificial and withal in part arbitrary, and therefore must be taken (if indeed taken at all), as only a further amount of description of the total action as possibly it is. But the process of the insight as a whole cannot, I believe, escape analysis into at least the four processes numbered above. Let us examine them.

I. *The emotion* (affect) concerned is liable to be any one of many to which the human dynamism is liable; in 'The Influence of Joy' I have listed about eighty feelings which in theory might thus serve to direct and to energize the behavior of the intuiter toward the related situation. Sturt in his 'Principles of Understanding' (1915) emphasizes sympathy as the emotion germane to this relationship: "One common cause of slowness of judgment is defect of sympathy. A man often fails to understand other people because his interests are different from theirs. . . . The quick-wittedness of women in dealing with a personal situation is mainly due to their power of ready sympathy." But there is a danger that the natural chivalry of most writers will designate as womanly sympathy what scientifically would more properly be denoted affective interest in general. On this supposition jealousy, curiosity, fear, anger, hate, even in short any dynamic, that is affective, reaction is

adequate to attract, direct, and hold the intuiter's energy toward and into the about-to-be-intuited situation. In a broad sense of appreciation (rather than that narrow one of kindly sympathy) we may well accept sympathy as the dynamic and kinetic starter of our quadruplex intuitive process. Beneath it clearly enough is human interest in the concatenation which living forever implies, by whatever precise affective name we handle it. It alone furnishes to intuition the *vis a tergo*, the impulse, which realizes it. But the dynamism of hate is at least equal to that of love.

II. *The process of comparison and then of inference*, substantially the essence of reasoning, has for intuition no special interest other than the circumstance that in intuition the process is at once quick, accurate, and wholly subconscious; yet that seems to be adequate reason why it should interest descriptive and explanatory psychology. Reasoning is a basal mode of mental activity existing in its essence everywhere, and always typical of the truest relationship of the ego and its effective environment, at least in those stages of this relationship when instinct in truth has become 'disinterested,' as Bergson says, 'and capable of reflection.' It is "formal logic" that has made reasoning unpopular; but thought must be libelled no longer as somewhat too recondite for scientific discussion, for it conceals in a mass of dialectical chaff grain too real, too dynamic, and always too important to longer remain lost. And logic will be hateful no longer than whatever length of time the dynamic theory shall require for the statement of the kinetic relationship of ego and environment in terms that all may understand. From the dynamic viewpoint the psychology of thought is seen to be still *alive*, and not merely Medieval and Scholastic.[1]

III. *The comprehension of the intuited situation*, our third intuitional component, cannot be dismissed so curtly, for it involves not only a suggestion of the intuitive relationship, but a brief connotation of the concept 'situation' which we have so often already employed.

[1] See, for example, the writer's "How to Learn Easily" (Little, Brown & Co., 1916), especially the fifth chapter. To set forth somewhat more in detail the kinesthetic aspects of ideation is a task already begun.

The term comprehension is a fit one here, for it should mean for our present use just what etymologically it ought to mean — a taking-together, an understanding of some integration in its parts as well as in its wholeness. The integrated parts in this intuitional process are of the same derivation and of the same general nature as the factors of understanding elsewhere. Sense-impressions, often marvellously subtle, from without, percepts, stores of concepts within, memory 'fringes' of experience first- or second-hand, innate tendencies to integrate or to analyze, kinesthetic 'vestigia' serving as cues to imitative interpretation—all that undescribed, but inherently describable, vast complex of conscious and subsensory mentality which expresses for us *the meaning of behavior*, be it in ourselves primarily or in others. The clever 'clairvoyant' of today, the Stone-Age priest of old, Hans the horse, 'Sherlock Holmes' all had this comprehension clear because these intelligible elements to them were explicit, and symbolic of meaning. For business purposes the emotion need not be obvious, indeed may be conspicuous by its absence in the hackneyed 'palmist' and the kind of comprehenders whom she typifies.

But what does one mean by the intuited '*situation*'? Inasmuch as intuition has no assignable limit of range or acuity it certainly were illogical to limit, either, the situation which the process explains. On this basis I propose to simply denote situation (here as elsewhere, wherever in short, reality is in relation with consciousness) as *any appreciable relationship whatever, ejective, objective, or subjective, so long as not irrational*, and including, therefore, pure caprice. By irrational we can mean only fortuitous in the metaphysical sense, but to attempt justification here is quite inexpedient, since the mutual bounds of chance and rationality, of chaos and cosmos, no man can pretend to set, and less and less may he pretend to do so with the advancement of learning and of insight into nature.

As any appreciable relationship whatever, then, in the rational world, 'situation' is delightfully simple to denote, but obviously only because it is inexpressibly and unimagin-

ably too various and too complex oftentimes for words to justify at all. And this viewpoint really *needs* no justification as long as kinesthetic vestigia supplemented by other immediate sensorial data can serve as cues to the beginning of the intuitional performance; for thus long even the human mind will consciously and subconsciously realize its environment more or less fully.

But of course a considerable proportion of actual intuitions or intuitive actions in our civilized human experience deal with a narrower range of situations, namely with those primarily ejective: intuition most often 'sizes up' some person's relationship to his environment either at a particular time and circumstance or else in general, as a habit. In the former case the intuiter would learn, by intuiting, what the person would do next, and the series of his behavior; while in the latter case the inquiry relates to that person's character. And here one sees part of the biologic answer to the question why women and girls are the expert intuiters among humans; obviously to protect them automatically from the strenuous and often unimaginative and therefore 'selfish' male. Indeed, it were not easy to overevaluate intuition in this respect to young women, sometimes and in some circumstances so irresistibly seductive and yet so helpless and so liable to irreparable harm. A common, the most common, intuitional 'situation' is, then, human nature and its behavior, and, most specifically common of all, men's characters in biologic relation to the intuiter, when women's characters are a necessary part of this complex but theoretically simple sexual, biologic situation.

IV. *An effective instinct to trust* one's intuitions was our fourth factor. It is plain that without this the rest were futile, and it is just as plain that endless generations of experience (say 30,000 of them?) have long since made this trust a coherent part of the mental process we are attempting to elucidate. This mind-confidence, so conspicuous in strongly feminine women and girls, which makes them trust their "feelings," their intuitions, their inspirations, impressions, over-soul, or whatever else it be termed at times, is

perhaps best made obvious to males by observing how frequently it is essentially lacking in themselves. Men trained by intense need and vocational practice to making quick judgments, be they trivial or be they important, do acquire a degree of true intuition. Frequently, too, male bluster pretends a true quick choice when in reality the pronouncement comes 'by chance,' at random—or else by true intuition. But, on the other hand, many men—those, *e. g.*, of 'judicial temperament'; those intelligent enough to know the supreme value of subconscious consideration; and those upon whom rests as a burden the responsibilities of life and death and happiness and woe—realize perfectly well that they *must not* trust their impulsive judgments too implicitly, for too frequently are they irretrievably wrong. And, if we cut out of our observational experience all cases of pure male obstinacy and bluff, with might to make it seem right, how much stronger is the proposition that men usually do not have this 'effective instinct to trust' their impressions which is so vital a factor of intuition.

With these four indispensable components of intuition in our minds 'on approval,' we would like next to examine into the physiologic aspects of this type of behavior. But we will not do so, at least not at this time. Here it is enough to point out that the behavior of the intuiter is that of enthusiastic intellectual emotion, of thought, of inward attention vivified by some feeling wholly acceptable and pleasing to the subject. The characteristic outpouring of adrenin, the characteristic heart-rate, blood-pressure, breath-rate of intuition we do not as yet know.

By way of a moment's respite, of restful change of focus, let us consider here that in general it is one of the "silent mysteries" of mind, why psychology does not more rapidly study the often practically important tertiary sexual characteristics. It is possible that some would insist that there are none,—none, at least, worth their valuable time and effort; that this bottomless crevasse of sex which so completely divides the entire living world in all other respects

into two opposed yet complementary halves, does not extend into the peaceful animistic realm of mind. For my part, however, I do not believe it, for I see a forbiddingly large fraction removed from the human nature which we psychologists crave to understand, were sexual mental differences entirely smoothed out. At any rate, the present remarks depend upon the presupposition that feminine intuition is a fact in need of study, together with its implications, and one of the most obvious and most important of the tertiary sexual characters—another of the complementary aspects of the sexes so much exploited by the phrenologists yet vitally important because so true. Havelock Ellis has set the pace—who follows in his train?

If the reader glance back over our intuitional analysis, it is conspicuous that a constant element of the 'situation' always implicated is the interrelated *character* of something or other, good or bad, trivial or momentous, living or non-living. Character, as Fichte and Royce and Emerson and wisdom in general tell us, is inherently purpose:

> ". . . , perseverance, dear my lord,
> Keeps honour bright: to have done is to hang
> Quite out of fashion like a rusty mail
> In monumental mockery."
> ('Troilus and Cressida,' III, III.)

Simple purpose, then, perseverance, and the rest, stand for much of the situation with which we deal; and at the base of intuition stands solid and strong the appreciation of motivity, an interpretation of human purpose, an habitual and therefore automatic tendency to put one's self in another's place, to make his problem seem as much one's very own as if it were so. Oftentimes, of course, the situation involves the motivation of numerous persons, not alone of one, or the comprehension even of a whole 'social consciousness' itself. The quintessence of the process seems to be most usually an appreciation of *motivity*, of primal cause, but more typically when in others than when in one's self.

With Professor Warren's acute analysis of purpose so

recently before us (see the *Journal of Philosophy, Psychology, and Scientific Methods*, Jan. and Feb., 1916) it would be perhaps superfluous to further seek the introspectible factors of motivity, for the two problems purpose and motivity certainly widely overlap. 'Forethought (anticipation); assent; potency-feeling; the self-notion; and the sense of fitness' are the five parts discovered by this observer in purposiveness. The assent, potency-feeling, and the sense of fitness are declared kinesthetic, and yet incidental; while forethought, 'the most characteristic factor, is an idea or image which carries with it a reference to the future . . . a real biological phenomenon' when kinetic; and the sense of fitness is a 'judgment that the experience corresponds' to the anticipation—'a factor very characteristic of purposive experiences.' So far we may follow, but when it is stated that purposive activity (and this alone concerns us in intuition) 'is characterized by only two of the factors noticed in the conscious experience,' namely preparation and adaptation, we have to express dissent, and wonderment as to how the adaptation is brought about else than by 'assent,' 'the potency-feeling,' and 'the self-notion,' each clearly kinesthetic. Without these, the 'entelechy,' so properly condemned by Warren, seems actually inevitable in the adaptive process.

Intuition, then, seems to the present writer to involve *the appreciation by the intuiter of the potential purposive activity* of the intuitee, the very essence of which activity is given to the former in ill-appreciated adaptive, that is kinesthetic, terms.

The intuiter feels in short the action, the behavior which the other's attitude toward his environment properly demands on his part. Then without realizing it clearly, she takes it for granted that the natural activity will eventuate—usually without error, as her long ancestral experience has found and, down the ages, made innate. Women, no more than men, have clairvoyant powers, the ability to read motives and thoughts, etc., on any basis whatever other than that of their own personal or inherited experience. And this experience, so far as related to activity, certainly seems adaptive,

that is, in its psychologic aspect predominantly motor and kinesthetic. The very essence of conscious adaptation psychologically is plainly kinesthesia, just as the essence of intuition seems to be adaptation in its potential phases in someone else.

This kinesthetic criterion on which a person may intuitively grasp an 'ejective' situation would seem in part to account for the emotional tone in the recognition, and still more surely for the understanding of its personal nature,—two of the four suggested factors of intuition. *Interpretation is wholly blind to us save on the kinesthetic basis*, as the writer has tried to show in some notes already printed on kinesthesia. Thus intuition stands not only for exteroceptive perception, but, in a still more intensive way, for proprioceptive sensitivity and appreciation. Kinesthesia is the very warp of all perception with the varied woof or 'filler' coming from the other senses and their 'centers.' Thus the modern dynamic explanation of behavior cannot possibly be ignored in any discussion of intuition, any more than the thoughtful physicist who is read up to date can slight the kinesthetic origin of our racial mind's concept of energy, force, and work. Philip,[1] by correlating with Newton's laws of motion, has already shown how far-reaching is this relationship into our basis for every 'situation' not purely metaphysical—if any such, indeed, there be as one *purely* metaphysical.

Again, then, it must be noted that the intuitive capability, like all others like and unlike, depends absolutely for descriptive psychology on the dynamic relations symbolized and indexed by *kinesthesia, the dynamic mental warp of our behavior-fabric*. It is interpretation in terms of the known and in a manner much as Royce improved on Tarde in regard to imitation. It alone makes intelligible whence an intuitess derives her awareness of expending energy, of stress and strain and shear, of causality, of a whole causal series, out yonder in that situation which she so quickly, quietly, but keenly evaluates. She is able to put herself in the other's place and to feel what that other feels and to know what that

[1] A. Philip, "The Dynamic Foundations of Knowledge," London, 1913.

other unerringly (barring caprice) will do, *only* because personal or inherited experience of such dynamic situations has given her an insight, as certain to her as daylight, into the kinetic series of events that must come forth. On any other known basis than this, the dynamic or kinetic basis empiricized as kinesthesia, dynamic index to our souls of our effective environment, the complex intuitive process has no meaning simply because it has no substance other than one *too esoteric for science to discuss.*

William McDougall in his "Body and Mind" is certainly rather ingenious in his arguments that meanings are independent of the action of the neuro-musculo-glandular coordinations. Yet it seems to the present writer ample refutation of such an unscientific presumption to remind all and sundry that *the only conceivable means by which these meanings as psychograms ever could have become explicit in the mind is through the perception-process, elaborated by central association.* Perception and association partly are bodily actions. Moreover, it is undeniable that these bodily neural actions persist, constitute the dynamic framework, so to say, of the active mind, and must be repeated, overrun, whenever a meaning, however subtle, suffuses the personality. These things are at the very heart of our understanding of behavior; as a neo-animist the writer, for one, does not wish to do else than to explain and to accept them.

Objective perception, perception of objects, with their recognition, meaning, and other relations get their actual start in the comprehension of including situations. Objects have no forced connection with our minds at all save as they represent for these minds and for behavior something with meaning, real meaning, use—save, in short, as they are interpretable in terms of our own activity. Sturt has made this really important matter as explicit as possible in his recent treatise on the Understanding already referred to: "It is important to notice," he says, "that in the order of mental development [phyletic and ontogenic], purpose and cognition of situation come before the recognition of distinct objects, *i. e.*, before the apprehension of persons and things.

To a superficial observer the order is reversed. . . . Animals and even men living under purely natural conditions, notice only those objects which they can use." Then Sturt illustrates by suggesting the contrasts in the behavior-reaction of a caterpillar, of a kitten, and of an author toward a fountain pen. "We may conclude, then, that creatures of the lowest intelligence cannot be said to recognize objects but rather to perceive objective systems or situations corresponding to the purposes whereby they seek satisfaction of their desires" (p. 203).

While this probably is as true in general as it is important and keen when applied to the phyletic animal range, it apparently is not observable in the actual human mind as a dominant principle of action. In fact, if I can adequately judge from the protocols so far received of an experimental study (in progress) into the psychology of meaning, there is a distinct, but perhaps not large, correlation between *efficient intelligence*, in a broad practical sense at least, and the tendency to apperceive *meaning as active behavior*, as action rather than as objects proper unrelated to activity. This empirical attitude toward meaning is most obvious in a comparison of morons with normals, but, unless I misread my experimental results so far, it is also discernible in comparing thoughtless ('shallow') normals with those who by habit think into the real relations and into the dynamic essentials of things. Meaning is for some non-existent in a given character or situation; for others its essence is some object; for others its import is its action on behavior; for still others its meaning is frankly only its active relationship to an active environment. *Humans* of 'low intelligence' apparently may *not* be said to 'perceive objective systems or situations corresponding to the purposes whereby they seek satisfaction of their desires' or anything else, for if they perceive anything at all that is denotable, it appears to be uncompromising objects, stark and passive, relatively unrelated to themselves or to the remainder of the always energetic environment. Lack of *intuition* obviously comes in here—lack of insight into the purpose and the realest mean-

ing of things. The implication of these above considerations for our notion of intuition meets the reader's understanding face to face.

From several angles, then, we may presume it demonstrable that the entire intuitional affair, save its product, is one of the highest possible *intelligence* and at the same time characteristically subconscious. In fact, no better example of this common association in mental activity of keen intelligence and absence of conscious process, is at hand than this. If we think, with Münsterberg for example, of the soul as 'a system of purposes which remains identical with itself in developing its potential acts as real experiences' we have in intuition, as almost nowhere else, a typical example of soul-activity. On such animistic basis, shall we reject the existence of psychological subconsciousness? Here if anywhere is that meaning which lends causal connection to unconscious intelligent associations.

It certainly is something outside the range of physiology and of neurology—and therefore within the range of mind—that one person can by processes of reason and of feeling, often wholly unconscious, comprehend a situation characteristically spiritual in another person's mind,—a motivation-reaction of that second person to his environment. Why do a few still let a matter of arbitrary definition refuse to events as clearly spiritual as this the adjective *mental?*

Psychology surely has and need have no fear of losing its scientific identity, of being gulped down and digested by physiology or by neurology, when so large a horde of problems plainly mental and evidently causal like this one press upon it in a crowd for immediate solution. Physiology here, in such a case as intuition, has not much satisfaction to offer that will convince the unprejudiced. Physiology certainly offers for study, and ultimate understanding perhaps, the *mechanism* of so recondite a common experience, but it does not offer—nor can it ever, it seems to me—that unexplained remainder by which woman's sensitive keenness and woman's sympathy leap the restrictions of even the human nervous

system, of the musculature, of adrenin, of *energy* vitalizing the stupendous cortex of the human brain and giving it these unique capacities. And what of it, if part of this spiritual process is in the dark? Is it material, neural, because of that? If not then material, is it not mental? Nor is the true believer in the propriety of terming subconscious processes distinctly mental, going to consent much longer to be ruled out of court as a proper student of psychology on the trite old argument that psychical succession offers 'no causality' to the uniformity-seeking mind of the scientist. The new soul is certainly coming back and the *new* soul means something! An 'asymptotic regress toward a pure subject of knowledge' no longer, the 'inner' purposiveness and the 'outer' activity are joining hands joyfully in full sight of the unlearned man, who bids them glad welcome in the positive hope at last that these two made one will help him to really understand himself—if not his God.

Intuition, then, and the comprehension of a total situation of whatsoever kind, involving motive which intuition implies, is in a way and in a degree a real criterion of real intelligence in its most significant values. From this deep way of looking at the matter, the feminine mind is more evolved, more *intelligent*, in short, than is the mind of the male. Obtuseness stands for abnormality or for relative lowness of human grade; intuition for a high degree of that which mind is especially meant to serve—the safeguarding and the furtherance of the individual. From such considerations it would appear that intuition deserves far more study and consideration than thus far it has received.

Its abnormal conditions, especially its derangement or its lack, have not received at the hands of the test-systems the attention which they inherently deserve. In my intimate blood-pressure work with mental defectives I have had an excellent opportunity to compare 'psyche' and 'soma'; the more subtle phases and aspects of mind proper with the familiar conditions of muscle, circulation, respiration, motor control, automatism, etc., which 'underlie' us as humans in common with the brutes. Passivity merging into obtuse-

ness is conspicuous. The contrast between the fine active physique of a middle-aged Negro farm-hand and his 6.6 yr. point-scale intelligence, as shown not only in his hemobarogram but in his social (extero-active) behavior, is an instructive thing for several interests. There is obvious a lack of the subconscious associative niceties; the term astuteness does not pertain; that natural eagerness to finish and do something else is commonly lacking; extraneous and future comprehension, planning, purpose, are not there. The childish men and women exhibit no intuition and no curiosity as to the reason why I work so intimately with them for an hour or less, but they show plainly enough sometimes all the intuition that a six-year normal girl exhibits that the soft silk and rubber cuff of the pressure-gauge may hurt them. In one instance a woman 42 years old, 1.6 years Yerkes scale, burst into tears as she felt the unfamiliar constriction-sensation in her arm. Mental defectives, especially female, have intuitions surely enough, but they are of that simplicity of 'situation' that they merge into the most basal of the emotions—intuitions in a sense, carnalized and made hereditary by thousands of generations of continual activity, reduced so that the 'situation' has resolved itself into the relatively simple 'object' of the emotion, usually its occasion.

We come then to another sanction for discussing intuition: it is a criterion of the practical reason, of human sanity. We have failed above to be intelligible if it is not now obvious that the general practical intelligence of any animal, brute or human, has a valid index or criterion in that animal's 'intuition'; and so too for the lower ranges of the human intellect and the intelligence deranged. Here, in fine, is a definite criterion of mental normality. The writer has already briefly discussed this in an earlier article from which two paragraphs may be quoted by way of reiteration:

In attempting to define the difference between normal and abnormal mind we have come as a final criterion to something at least theoretically more satisfactory than either of

the preceding considerations. It emphasizes anew the both vulgar and classic opposition between the common and the egotistic good, between altruistic benevolence and selfishness. As an individual and with only individual responsibilities and duties the deranged man's conduct may be as satisfactory and complete as that of one classed empirically as sane. His nutrition may be as good, his form as sleek and comely, his strength normal, and his body to all appearances, perhaps even microscopic, wholly sound. Even the mental aspect of his organism may possess all the requisites of proper function—good sleep, clear ideas, memory unimpaired, imagination very likely better than the average, sensations and feelings normal, and, be it emphasized, conscience wholly clear. With all of these and what they imply, with soul and body in evidently proper order, a man or woman may yet be the most dangerous of lunatics, the maddest of the mad. But turning to the vast *social consciousness* of which this willing subject is part, inquiring in what degree of harmony this person's life-purposes stand therewith, and the discrepancy at once is seen, his lack, the nature of his inward dissonance, the reason for his life none too much confined. Humanity's consciousness, too, has purposes and plans, and they proceed inevitably to their grand fulfillment. It is because the purposes of his suspected person (and whether free agent or automaton matters not here) run counter to this evolutionary current, that unavoidably he is overwhelmed and forced beneath and drowned. Neither anatomical nor physiological nor psychological nor yet personal, in a sense, is the deranged subject's defect, but it is *sociological* and against the evolving purpose of the race. Any given case may, of course, be defective in each of these respects, as most are in some of them, but the defect essential to abnormality certainly finds its place relating far outside the individual in the complex intention of the race, be that intention moral or unmoral, racial or cosmologic, ill or good. This is the one unrelative standard by which all vital subjects may be judged. To be insane is to be out of tune, not with the laws of psychology or of physiology, nor yet of the state,

but with a broader and more essential tendency—the purpose of the world, it may be of the universe.

To this conclusion not metaphysics alone, but also empirical science points. *Reason* is the aspect of mind which men in general have deemed the highest and most dignified power of soul, be it called by whatever particular name. It is that endowment by which certain species, or certainly one species, of the animal kingdom understands the most real nature of things and their relations—the *meaning* of the ceaseless life of change in which all our experience is passed. Reason is the just comprehension of cause and effect, or common sense. Now only a part of the accepted varieties of insanity imply disturbance of this, the crowning power of mind. Mania, for example, is only an unusual hurrying of the psycho-physical action of the higher animals, involving as essential no disturbance other than one of a temporal sort. Melancholia is, on the other hand, the reverse of this, a slowing of the life, a too long continuance of painful thoughts. Dementia paralytica is more of a bodily disease than the two just mentioned, and epilepsy, dementia, idiocy, even more. It is in paranoia that we see a loss of reason in the technical sense of the word, for it is a disease characterized by a confusion of the relations of cause and effect quite as much as by the systematization of delusions based thereon. Here is a state of mind wherein the meanings and purposes of things are deranged, a general disturbance obtaining in the egotism of the subject leading him into greatly wrong relations with himself, with things, and with society at large. This is the typical instance of mental abnormality where is seen at once perverted psychic action and a basal disagreement with the racial plan.[1]

Of this out-of-tuneness, of this fundamental disharmony or discord with the social values, there is not a more accurate nor a conciser concept than intuition. It expresses more in a small space, this 'word-handle' of a general idea, than any other that may be found, perhaps, explanatory of *the practical effective unreason of man*, and that too without betraying the

[1] PSYCHOL. REV., 1898, 5, 506–510.

necessary individualism of a valid philosophy; and this thing some other criteria of mental abnormality cannot do. Were we somehow less dependent than we are on our spiritual environment, this intuitional criterion would be less representative. But as it is, as we are, intuition expresses very much, for it suggests directly that appreciation of the basal life-relationships, *causal*, rational, social as well as psychologically personal, on which alone our whole important concept of abnormality has any modicum of meaning.

It can be practically applied as a criterion, as a test, far more elaborate than Healy's pictorial completion device; which however is clearly along this line. Class study by means of a questionary given to normal students and collegians would soon develop data which would test a student's native intelligence somewhat better at least than the absurd agonies in algebra over which so many discourageable boys and girls are just now worrying. But tests are outside our present situation.

Incidentally it should rejoice every man and boy that the biologic source of our very being, womanhood, undoubtedly is the richer of the two sexes in this intuition, this useful measure of our common human always yet divine intelligence. Is not this richness a criterion in a way, of woman's superior intelligence?—not perhaps to politically govern in this world which is still one of *might* and maddening terrors of force and blood, but in all of those more permanent and less savage aspects of mentality which will watch our earth 'grow cold.' Yes, even at a risk of supplying ammunition to the suffragettes, the writer for one must maintain that the intelligence of the human female, tested by some of the most basal and certain tests in any 'system,' is the psychical superior of men. If the general scientific recognition of this interesting fact come late, it is largely because the criteria of superiority have been below the proper human ideal. When at last *skill* shall have replaced *strength*, the general recognition will have come, and a new chapter be written in psychology.

# THE INTELLIGENCE EXAMINATION AND EVALUATION

## A Study of the Child's Mind

## (Second Report)

PART II.

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*New York*

### IV. The Tests for Comprehension

Under Comprehension, we first test (*a*) the *comprehension of numbers*. Pennies (and stamps or stones) may be used. Binet found that at four, half the children tested count four pennies, while at five only the retarded fail. At six one third of the children count 13 pennies correctly, at seven all of them.[1] In a later test Binet used three single and three double sous (for which Goddard substituted one and two cent stamps). In this test many succeeded at seven, all at eight. Binet has the child touch the coins consecutively. Ziehen, on the other hand, who in testing numbers suggests 4 to 7 or more small stones, does not permit the child to touch these, nor aid in the task through moving of fingers or nodding of head. He asks, "How many stones are there?" Only if this cannot be done does he allow the child to touch one stone after the other. (The latter is the optic-motor counting, the former the purely optic, and the former entails greater abstract number comprehension and is more difficult. The latter may often be accomplished even by lightly imbecilic children—as also the counting of sounds [acoustic impressions]—up to the number of 6 or even 10.) The severe imbecile and idiot have mostly no conception of num-

[1] Bobertag, *l. c.*, p. 65, holds this test too easy, and believes that almost only the feeble-minded fail in it. For him it is scarcely a 'psychological test' but rather a pedagogical one. The same is true, he thinks, of the test with three single and double sous.

bers whatsoever, or only to 2 or 3.[1] One may likewise place 20 stones before the child, and say, "Give me 3 stones, or 5," etc.[2]

In making change one plays at 'make believe' with the child—as Binet suggests—giving him a quarter, and buying 4 cents' worth of something or other. The correct change must then be returned to you. The child has put in front of it real change in the form of 10 pennies, 2 nickels, 2 dimes, 1 quarter and a half dollar.[3] All succeed at nine years. Children who come in touch with money will, of course, do these tests better than those who rarely handle it. Ziehen, however, points out that even severe imbeciles at times gain a very fair knowledge of coins.[4]

One may also ask, "Which is greater, 6 or 10; 100 or 50; 100 or 500?" "Which is less, 10 or 5?" etc., "Many or a few?" But in these questions we are leaving the concrete and involving relations.

Under (*b*) we ask the child—according to Ziehen—to *isolate* certain qualities or parts of a familiar composite. "What are the qualities of sugar?" (whiteness, sweetness, etc.). "Of what is a storm composed?" or "What is a street, summer, a city, a concert, war?" etc. The opposite process, that of melting together single facts into a whole, as of rain, thunder and lightning into the concept "storm," may also be tested. "What is it" one will ask, "when it rains, thunders and lightnings?" or "What do you call it?"[5] This is termed '*complexion*' (Komplexion).

Still another psychological process belongs to this group

[1] It is interesting to note that the comprehension of numbers comes late in the development of intelligence. The lower animals have scarcely any real knowledge of numbers. It is but little better with primitive man. The aboriginal Australian can rarely count his five fingers, and no Australian language contains numerals above four, all numbers beyond this being described as 'many.' See Sully's 'Outlines of Psychology,' p. 283–4.

[2] Ziehen, 'Geist. der Kind.,' 1915, p. 66.

[3] These coins have been suggested in place of the French pieces.

[4] 'Die Geisteskr. d. Kindesalt.,' 1915, p. 63.

[5] Ziehen notes that most feeble-minded children get the partial idea of a composite more easily than the reverse; *i. e.*, if you ask "What is a storm?" they may answer, "It rains, it lightnings, it thunders." But when the question is put as above, "What is it when it rains, etc.," they cannot answer (*l. c.*, p. 63).

# THE INTELLIGENCE EXAMINATION AND EVALUATION

## A Study of the Child's Mind

## (Second Report)

### PART II.

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### IV. The Tests for Comprehension

Under Comprehension, we first test (*a*) the *comprehension of numbers*. Pennies (and stamps or stones) may be used. Binet found that at four, half the children tested count four pennies, while at five only the retarded fail. At six one third of the children count 13 pennies correctly, at seven all of them.[1] In a later test Binet used three single and three double sous (for which Goddard substituted one and two cent stamps). In this test many succeeded at seven, all at eight. Binet has the child touch the coins consecutively. Ziehen, on the other hand, who in testing numbers suggests 4 to 7 or more small stones, does not permit the child to touch these, nor aid in the task through moving of fingers or nodding of head. He asks, "How many stones are there?" Only if this cannot be done does he allow the child to touch one stone after the other. (The latter is the optic-motor counting, the former the purely optic, and the former entails greater abstract number comprehension and is more difficult. The latter may often be accomplished even by lightly imbecilic children—as also the counting of sounds [acoustic impressions]—up to the number of 6 or even 10.) The severe imbecile and idiot have mostly no conception of num-

[1] Bobertag, *l. c.*, p. 65, holds this test too easy, and believes that almost only the feeble-minded fail in it. For him it is scarcely a 'psychological test' but rather a pedagogical one. The same is true, he thinks, of the test with three single and double sous.

bers whatsoever, or only to 2 or 3.[1] One may likewise place 20 stones before the child, and say, "Give me 3 stones, or 5," etc.[2]

In making change one plays at 'make believe' with the child—as Binet suggests—giving him a quarter, and buying 4 cents' worth of something or other. The correct change must then be returned to you. The child has put in front of it real change in the form of 10 pennies, 2 nickels, 2 dimes, 1 quarter and a half dollar.[3] All succeed at nine years. Children who come in touch with money will, of course, do these tests better than those who rarely handle it. Ziehen, however, points out that even severe imbeciles at times gain a very fair knowledge of coins.[4]

One may also ask, "Which is greater, 6 or 10; 100 or 50; 100 or 500?" "Which is less, 10 or 5?" etc., "Many or a few?" But in these questions we are leaving the concrete and involving relations.

Under (*b*) we ask the child—according to Ziehen—to *isolate* certain qualities or parts of a familiar composite. "What are the qualities of sugar?" (whiteness, sweetness, etc.). "Of what is a storm composed?" or "What is a street, summer, a city, a concert, war?" etc. The opposite process, that of melting together single facts into a whole, as of rain, thunder and lightning into the concept "storm," may also be tested. "What is it" one will ask, "when it rains, thunders and lightnings?" or "What do you call it?"[5] This is termed '*complexion*' (Komplexion).

Still another psychological process belongs to this group

[1] It is interesting to note that the comprehension of numbers comes late in the development of intelligence. The lower animals have scarcely any real knowledge of numbers. It is but little better with primitive man. The aboriginal Australian can rarely count his five fingers, and no Australian language contains numerals above four, all numbers beyond this being described as 'many.' See Sully's 'Outlines of Psychology,' p. 283–4.

[2] Ziehen, 'Geist. der Kind.,' 1915, p. 66.

[3] These coins have been suggested in place of the French pieces.

[4] 'Die Geisteskr. d. Kindesalt.,' 1915, p. 63.

[5] Ziehen notes that most feeble-minded children get the partial idea of a composite more easily than the reverse; *i. e.*, if you ask "What is a storm?" they may answer, "It rains, it lightnings, it thunders." But when the question is put as above, "What is it when it rains, etc.," they cannot answer (*l. c.*, p. 63).

and may be tested. When a child forms the conception of 'bird' from seeing many birds and noting the resemblance of many animals that have wings and beaks and that fly, or the conception of 'furniture' from seeing many pieces of furniture, this is termed '*generalization.*' Hence, we ask, "What is the general name you give to eagle, goose, sparrow, swan, etc.?" (Or the general term for chair, table, sofa, etc.) One may also reverse the problem, asking for 'all the birds you know,' or 'all the pieces of furniture, or trees, flowers, tools (adverbs) etc., you know'[1] (or, better still, ask 'name me *some of* . . . ,' etc.). Only the defective child would name snail or frog among the birds.

These three processes, *isolation*, *complexion* and *generalization*, Ziehen[2] holds as fundamental in the building of ideas. The three processes constantly interlace in the most intricate and manifold ways, and generate our innumerable conceptions and ideas. The child, very early, through these processes notes relationships and sizes up the unfamiliar. It is through generalization that we classify and establish order in our immense accumulation of separate and incidental facts.[3] Generalization is also abstraction.[4]

Though these three processes may be examined separately,

[1] This is termed "*specification.*"

[2] Th. Ziehen, 'Leitfaden d. phys. Psychologie,' 9th edit., Chap. VIII.; or 10th ed., p. 292, et seq.; 'Intelligenzprüfung,' 1911, *l. c.*, p. 29. See also W. Preyer, 'Die Seele des Kindes,' Leipzig, 1905, p. 235.

[3] So Meumann also writes: "The fundamental process of thinking (Denktätigkeit) which no doubt commences in the child with the earliest beginnings of speech, is the classification of ideas according to grades of generality (or generalization—'Allgemeinheit'), Vol. II., p. 426. That one idea falls under another, continues Meumann, we know instinctively, and without calling up clear definitions of both. Meumann makes his tests as follows: He says to the child, "I'll name a thing and you are to give me the class (genus) to which it belongs," and he elucidates with an example. With younger children he gives examples of analogies, and then, placing a written list of words before the child, asks it to do the same.

[4] That is, generalization is dependent on abstraction; but abstraction does not involve generalization. Thus Hamilton says as to forming abstract general notions: "this is done when, comparing a number of objects, we seize on their resemblances; when we concentrate our attention on these points of similarity, thus abstracting the mind from a consideration of their difference; and when we give a name to our notion of that circumstance in which they all agree." etc. (Hamilton's 'Metaphysics,' Bowen edit., p. 465–7.)

they are probably best probed collectively in the following test (*c*) of *Differentiation*.

In this Differentiation test the point of *comprehension*, as such, is more readily focused upon, and without forfeiture to language ability,[1] chance, etc., as is the case in the matter of defining (see next test), and, as Binet notes, does not depend on instruction, but brings into play the natural good sense of the subject.[2]

Ziehen gives at least 4 to 6 sets (see our sheet), and affords the child ample time to consider. Binet, on the other hand, gives three pairs (butterfly and fly, wood and glass, paper and pasteboard),[3] two out of which must be correctly answered, and this must be done within two minutes in order to pass. At six one third of the children succeed, at seven nearly all, and *at eight, all.* Bobertag's statistics are less satisfactory: at six but 5 out of 30 passed, at seven, 52 per cent. of 42 children, at eight, 73 per cent. of 40 children; at nine, 93 per cent. of 33.

In a more recent publication[4] Ziehen gives the following age norms: Hand—foot, at the latest at five; cow—horse, at five to six; bird—butterfly, water—ice, at seven to eight; tree—bush, lend—give, at nine; garden—woods, at nine to ten; mistake—lie, at ten to twelve. This applies to the city child. In country children the age norms may be somewhat different.

It is probably best not to ask blankly, "What is the difference between . . . ," although the older children will understand this; one had better give an example, or explain the matter. Thus, if the first question is not understood or answered, Ziehen asks, "How do you tell, on the street, that an animal is a cow or a horse?", and if this fails, 'are they birds or flowers?' etc. Binet proceeds as follows: "You know what a butterfly is?—and you know what a fly is, too? Are they alike, a butterfly and a fly? Why not? In what way are they not alike?"—and in the same way the other

[1] The debile (or moron) of fine family may be far ahead of the normal uneducated individual in this respect. (Ziehen.)

[2] Binet terms this test the comparison of two objects from memory.

[3] Goddard also gives as alternatives 'horse and cow; stone and egg; grass and tree.' Meumann first asks (*a*) for the differences, and then (*b*) for the similarities. Among his pairs, beside the above, are box-basket, streetcar-train.

[4] 'Die Geisteskrank. des Kind.,' 1915, p. 68.

words are taken up. A real difference must be given. Yet some experience is necessary to know how to evaluate a reply. Such an answer as (to the words 'steps—ladder')—"In the ladder air is between," must, according to Ziehen, count as correct.

In commenting on Knowledge, I said that knowledge was really a 'differentiation of matter'—a *differentiating* between things. The normal process, in the young, probably, is first of noting similarities—assimilating—and then differences.[1] But directly a child begins to observe, and this is very early, both processes take place simultaneously. "Although in forming the concept 'animal,'" writes Sully,[2] "we are explicitly setting forth similarities among diverse things, we are implicitly marking off the class from other things (plants and inanimate objects) which lack these similar features . . . . Thus the process of defining a class-name includes in its most complete form an examination not only of things denoted by the name, but also of things not so denoted, in order to see what features they are wanting in. This consideration of differences becomes a prominent feature in the marking off of one idea from a kindred yet partially dissimilar idea, as metal from mineral, wise from learned, and so forth, a process that plays a large part in the definition of general names. Finally, in what is known as logical Division or Classification, where things are systematically arranged in higher and lower groups, attention is paid at once to points of similarity and to points of difference."[3]

When we come to the subject of *attention* it will be seen that the feeble-minded child's attention flickers too much and rests nowhere long enough to observe sharply, hence its power of differentiating is decidedly thwarted or nil. This is especially brought out in the matter of abstract ideas. On the other hand, the better mind is keen in observation (and

[1] Not that one is more difficult than the other—though it is usually assumed that finding similarities is easier. The difficulty depends on what things are to be compared, and what knowledge the individual has of these things. See Bobertag's comment, *l. c.*, p. 96.

[2] J. Sully, 'Outlines of Psychology,' p. 286.

[3] *Cf.* citation from Hamilton, p. 486, footnote.

accordingly acute in differentiating), and for such knowledge rapidly grows.

Test (*d*) that of *defining*, is not a very safe test, at least in Binet's form, nor by any means easily evaluated. Definitions in themselves are difficult. They involve not only language ability but language dexterity. Even for adults they prove sticklers, having a tendency to disconcert, and causing confusion. Ask an adult, for instance, as Bobertag suggests, the definition of 'a whole,' 'a condition,' or, 'what is meant by truth'! Children will frequently parry by giving an example instead, *i. e.*, "What is wisdom?"—"Wisdom is when you are overheated and don't drink ice-water."[1] Many definitions, too, with children, are school-drilled, and show up memory—scarcely always good memory—not comprehension. So Gross (*l. c.*) tells of a twelve-year-old girl giving as definition of table: "A quadrangular board (or four cornered) with four legs." This answer also shows how the child is wont to use a single instance to represent the *general* conception (for there are round, oblong and other tables, too). Thus, again, "What is a thing?"—"A thing is a table." "What is a sheet?"—"A sheet of paper."[2] There is no doubt at all that the boy giving the above example of wisdom had quite the proper conception (within a boy's limitations) and could *differentiate* between a wise and an unwise thing. But what a muddle he might have made of it if forced to stick to a definition proper! So we ourselves, when striving to make things clear to the conception of another, without too much effort, use examples instead of definitions. Hence, the parable. In fact, the logical classifying of things is accomplished in most people (according to Meumann) with instinctive certainty, even though often enough a definition of the idea cannot at all be given.

Nevertheless, in spite of these seeming difficulties, the

[1] Cited from Messer by K. Gross, 'Das Seelenleben des Kindes,' Berlin, 1908, p. 215. Other like examples given (cited from F. Wolff) are: "Tall—is if a tree is very big"; "Vain—is if you always look in the glass."

[2] Still another characteristic of children's defining is their bias toward action, and especially in relation to use or purpose. "Poison—is what one gives to mice"; "A knife—is to cut meat with."

definition has been admitted as a desirable test of the child's intelligence, inasmuch as the ability to define appears to undergo certain characteristic changes in the child's mental development. So, Meumann[1] notes as many as six changes, or methods of reply, only three of which I shall give here:

1. (The earliest) by replying with an example.
2. (*a*) By defining through terms of usage or employment;
   (*b*) Or, in the case of a person, by naming at least one of his chief activities (*i. e.*, "What is a king?"—"One who rules his people");
   (*c*) Or, in the case of abstract ideas, the statement of at least one inherent distinguishing feature (*i. e.*, "goodheartedness—is helping one who suffers").
3. Through analytical description.

Etc.

Binet, on the other hand, recognizes three methods (définition d'objets), the *first* being with gesture only, the child pointing to the thing, and remaining silent, or again, saying, "It is this," or by repetition (*i. e.*, "What is a fork?"—"It is a fork"); the *second* by defining in terms of use only (*i. e.*, "What is a chair?"—"It is to sit on"; "A horse?"—"To pull a wagon"); the *third*, in terms superior to use. He assumes the second type of defining as normal for the average child in the sixth year (at four half the children do so, at six practically all); and the third type for the average child in the ninth year (half the children in the seventh and eighth year defining thus). The words he employs for the tests are 'fork, table, chair, horse and mama.' Three out of the five must be acceptable to pass the test.

Bobertag[2] subjects this defining test to a thorough and excellent criticism. For him it is one of the most interesting in the series, though, in the form given by Binet, *wholly useless*. The fundamental idea however is very good, and may be made serviceable. Bobertag, like Binet, concludes that most 5- and 6-year-old children are able (either 'without'

[1] 'Vorlesungen,' *l. c.*, Vol. II., p. 430.

[2] *L. c.*, p. 50, et seq.

or 'with' a little necessary coercion), to define, or rather *explain*, all or several of the five given words in terms of utility. A few, he found, will answer through repetition, and a few in some nonsensical way. As the age advances these answers in terms of use decrease, but do not entirely disappear. Answers in terms of material, or through description, also occur, but are not common, and, likewise, lessen with the advance in age. On the other hand, answers in terms of class names (genera) which before the age of eight almost never occur spontaneously, now increase and finally obtain (save for a few utility answers) almost entirely. There are two levels here, then, which characterize the intellectual development of the child, the process advancing from description, in the widest sense, to defining in terms of class-names.

The reason the Binet tests go wrong in this appraisement is shown first by the fact that there are quite intelligent children who make an effort to answer, and remain speechless, or say "I don't know." Of course they know a fork, and if given the proper clew as to what is desired, would not only answer but answer possibly even better than the others. These children size up the problem, however, in too difficult a way, think it a bigger problem than it really is, and therefore stand fazed, just as the aforesaid adult questioned suddenly as to 'truth,' 'a condition,' etc. Change the form of the question to 'Of what is . . . ,' or 'Out of what material . . . ,' or 'Out of what parts . . . ,' and the answer comes easily enough. There are other children again who appear to be making conscious effort to give a good answer, and are heard to repeat to themselves 'is a . . . , a . . . ,' then give it up, and say "I don't know." In these latter cases it is plain that the child strives for a real definition, or, at least the beginning of such, or class-name, believing the type of answer necessitated in the form of the question: "*What is a* . . . so and so?"—"*A* . . . *is a* . . . yet being too young to define in terms of genera, can not get clear of the tangle, and sticks. If you would say to this child '*Of what is* . . . *?*' or '*For what is* . . . *?*' etc., it would

not fail. In other words, a child may feel itself constrained to answer in terms implied in the question—and not be equal to this. Again, it may start the series with replies 'in terms of use'—for, after all, a fork for most of us is *something to eat with*, and a chair, *to sit on*,—and then, having begun that form of reply, feels that it must go through the entire series in this same way—a form it would probably not use in the instance of horse, soldier, mama, etc. (certainly not if an older child) if it thought it was at liberty to alter the form. One notices that some—the more intelligent—children actually do so, as if overcoming a difficulty, and with noticeable relief to themselves. *Here chance, then, plays too big a part to give validity to the test.*

Bobertag, therefore, suggests the following: a longer list of words should be used, and such as can be easily defined, (1) by the younger child—in terms of use, (2) through description, and (3) through class-names or genera (Oberbegriffe), *i. e.*, fork, chair, tongs (Zange), cake, doll, cab, horse, soldier, penny, rose. These words have also a special arrangement: for the first form of definition they become progressively more difficult from first to last; for the third form of defining they increase in difficulty in the reverse order, from the last to the first (rose to cab being fairly easy, doll to fork rather difficult). One then tests out the three forms, or at least the first and third, with this series of words, *intimating the type of answer desired in the manner of asking the question*, or through an example; thus, "What is a fork,—a fork is for . . . ?" or give the entire, 'for eating,' and then proceed with the remaining words. When eliciting the third form, one starts in the reverse order, and Bobertag asks, "A rose and a violet, they are two what . . . ?" then penny and dollar, soldier and hunter, horse and dog, cab and omnibus (or stage), doll and ball, cake and roll, tongs and hammer, chair and table, fork and spoon. If one finally still desires the descriptive form of answer, one provokes this with "How does a . . . look?" etc.

Here, then, we get some idea of the difficulty of evaluating 'definitions,'—a far greater difficulty than the French tests

imply—and the danger of an unfair failure, to which even the intelligent child is thus subjected. It is no easy problem, this gauging of intelligence through defining, it is one scarcely as yet specifically determined. Bobertag's criticism also shows especially well how far from the mark the "cut and dried" Binet test (and testor) may go.

*Abstract ideas*, (*e*), are not in themselves easily comprehended by normal young children. There is a dawning around nine or ten, and only at eleven we expect a fair understanding of such.[1] It is here that the weak-minded easily reveal themselves, even the higher types, their capacity for abstract thinking being decidedly small. In consequence they show an abnormally meager ability to differentiate the essential from the unessential, the probable from the improbable, etc.[2]

It is interesting to find that studies in word-association[3] also disclosed that children between 6 and 12 or 13 associated, for the most part, *concretely* (and with 'individual' as opposed to 'general' associations) in contradistinction to adults, who associate mostly *abstractly*,[4] and that only from about the thirteenth year on did they appear to grasp abstract logical relations (cause and effect, etc.). Ziehen found that this "concretism" was characteristic of the clever or more talented children up to the twelfth or thirteenth year. The less clever or less bright children gave more abstract associations! This was also substantiated by Meumann.[5] Ziehen

[1] Binet gives the words charity, justice and goodness in the twelfth year tests (formerly in the eleventh year). Two out of three must be passed. At ten years one-third succeed; at eleven the majority. Bobertag's statistics were 11 children out of 36 (31 per cent.) in the tenth year; 20 children out of 36 (56 per cent.) in the eleventh year; 24 out of 32 (75 per cent.) in the twelfth. Meumann gives tests for abstract ideas in the eleventh, twelfth, and succeeding years. At eleven he asks for "pity," "justice," "envy," "friendship," "family," "sin."

[2] See G. Störring, 'Vorlesungen über Psychopathologie,' Leipzig, 1900, p. 399.

[3] See Ziehen, 'Die Ideenassoziation des Kindes,' Berlin, 1898.

[4] So, Compayré also comments: "Does not the secret and art of writing for children lie in the fact of knowing how to avoid abstract and general expressions, the collective and condensed words, and, on the other hand, in knowing how to multiply the concrete expressions, and the details?" ('Evolution intellectuelle et morale de l'enfant,' Chapt. II., Pt. 4.)

[5] *L. c.*, Vol. 1, p. 499–500.

concludes that when a child prematurely approaches the adult type, that is, associates abstractly, it for the most part shows intellectual inferiority. The transition is at 13–14-.

Care must be taken in putting the test questions. Ziehen, for instance, gives a little story embodying the idea of envy, or ungratefulness, and then asks, "What would you call this?" *e. g.*, "A girl sees that another girl has a much nicer dress than her own, and begrudges her this (or, is unhappy because of this), as she would like to have it herself. What would you call that, or what would you say that girl was?" "I once helped a man out of a good deal of trouble, and now I myself am in trouble, and ask his aid, but he refuses to see me. What would you call this (or him)?" Again, one may ask for an example of envy, bravery, etc.,—which however, is much more difficult.

The abstract words taken from Binet's sheet (tests at the age of 13), "poverty, misery," etc., are very difficult. In the revised scale Binet placed them among the adult tests.[1] Taken separately the words are often better understood and defined (a kind of 'catch' being sometimes experienced in the similarity of the sounds and meaning) than when the difference between them is asked.[2]

Under this rubric of the abstract, questions as to *relations* are likewise in place. One may ask for the meaning of 'similar, larger, more, less, almost, mine, cause, effect,' etc.

Such tests may also be made with lists of ten words, having the test-person give 'opposites' to these words, or 'similars,' 'causes,' 'effects,' etc. Or again, questions of logical causal relations may be put, like "Why does one heat up in winter?" "Why does one use an umbrella?" "Why do some people wear glasses?" "What might happen if you would get drenched, or would eat unripe apples?" "Why does a river flow?" "What might be the underlying cause of a person's

[1] An adult (according to Binet) equals "over fifteen years."

[2] Bobertag omits these tests (in fact all those above the twelfth year tests) as being too difficult. Meumann uses the words 'avarice—thrift' and 'mistake—lie' in the thirteenth year, and 'King—President' (Binet's pair) at 15 or over. Binet puts 'King—President' among his 'adult' tests and asks: "There are three differences between the president of a republic and a king. What are they?" (*Cf.* test (*c*).)

being angry, sad, happy?" etc. Here, however, we are stretching comprehension well over into combination.[1] The feeble-minded individual does not grasp the relation of cause and effect, or of purpose, expedience, etc., or the relation between things and a value or worth. Hence they remain impractical, unreliable, unforeseeing and helpless. It is to be remembered, however, that this knowledge comes late to normal children.[2]

Under (*f*) we test *ethical and moral ideas*, that is, knowledge of right and wrong, etc.[3] The method of differentiation may also here be used, and we ask for the difference between mistake and lie, borrow and steal, lend and give, etc. (usually known at 13),[4] though the tonal feeling, which is better or worse, is already felt, according to Ziehen, at the age of 7 or 8. Examples may also be given, which are to be 'labeled,' or the child is asked for an example (of a mistake, lie, exaggeration, deserved and undeserved punishment, fraudulence, etc.). One proceeds best, however, by asking: "What should you do if you see someone lose a pocket-book? May

[1] Thus C. Burt used the analogy test as a reconstruction test. (*Br. J. Ps.*, 3: 1909). Finding analogies really belongs entirely under combination, so does the finding of associations according to cause and effect; but finding logical opposites entails no combinational ability.

[2] Binet asks for 'opposites' (of good, outside, quick, tall, big, loud, white, light, happy, false, like, rich, sick, glad, thin, empty, war, many, above, friend) at 15. He allowed the marking of *half-right* beside the correct ones, and the equivalent of 17 correct answers had to be given to pass. In such tests, however, much depends on the words chosen, for the results vary according to their difficulty. For data on this, see Whipple's 'Manual,' Pt. II., p. 79. Meumann (following the results of Ziehen's association studies) asks for 'reproductions' with logical example (classification of ideas as to cause and effect) at the ages of 11, again at 12 and 13. According to Ziehen they scarcely occur before the eleventh year, and if they do in the eleventh or twelfth they are spare and given slowly (mit geringe Geschwindigkeit). Therefore we must look for the general knowledge of such in the thirteenth or fourteenth year.

[3] These ideas are also *abstract* ideas, and really come under (*e*). It is best, however, to test this group separately, as the special problem of ethical conduct may be involved in the case examined.

[4] More recently ('Geist. d. Kind.,' 1915, p. 68) Ziehen places the knowledge of this (difference between mistake—lie) at 10–12. Should the child hesitate in differentiating 'lie—mistake,' Ziehen asks, "Which is done with purpose?" Or he continues, "When a boy takes jam, and it is discovered, and he says it was his sister, did he lie, or did he make a mistake?" "If a person in adding gets the result wrong, is that a mistake or a lie?" Ziehen especially recommends the question, "Why is the lie worse?"

you keep it, even if you are sure no one saw you find it? Why will you give it back? Why may one not steal? Why does one punish one who steals?" etc. Or one gives an example, and asks: "Would you have done so?" In the case of a delinquent one will ask, "Can one depend upon it that you won't do it again? Why wouldn't you? Why not on a good opportunity?" etc.

One may also ask,[1] "Who, in your eyes, is extremely good, and why do you think so?" "Whom do you hold as very bad, and why?" Or, "Who is your model (or ideal) of goodness, etc., and why?"

We must bear in mind that this examination tells us only if the individual tested has a knowledge of the difference between right and wrong—which does not, however, mean that such knowledge occasions right action, or that the individual will not go forth and do wrong, even though he has a thorough conception of matters ethical and moral. There are children who answer all the above questions correctly, and seem even to 'show feeling' in the matter, and yet, put to the actual test, will lie, steal, and act anti-socially. "To understand, to feel and to act ethically (or morally)," says Scholz,[2] "are three very different things." Nor do these tests touch upon the subject of responsibility for acts done.[3]

A cautioning word must be said regarding the test for comprehension of *time* (*g*). This is really not a matter of intelligence, but depends much upon instruction. Meumann

[1] Meumann, 'Die Untersuchung der sittlichen Entwicklung des Kindes und ihre pedagogische Bedeutung,' *Zeit. f. Pedagog. Psychol. u. exper. Pedag.*, 13. Jahrg., Heft. 4, p. 212. See also the article of Richter, 'Statistische Erhebung über die Ideale von Volkschulkindern,' same journal, p. 254.

[2] 'Anomale Kinder,' *l. c.*, p. 98.

[3] In the law, responsibility means a knowledge of right and wrong at the time and in regard to the particular act done, knowledge of right entailing (supposedly) right action. This conception is pathetically antiquated, dating back to Socrates. Psychopathology has taught us that this is by no means the case, and, in fact, that such an inference is decidedly erroneous. That mental defect has anything in itself to do with crime is likewise erroneous. These facts will be fully discussed in a paper by the author on 'Delinquency,' to appear presently. On *Responsibility* see the interesting study by Robert Jones in *The Practitioner*, London, Apr., 1913, Vol. XC., No. 4, p. 653. See also 'Die Prüfung der sittlichen Reife jugendlicher Angeklagter und die Reformvorschläge zum Nr. 56 des Deutsch. Strafgesetz,' by M. Levy-Suhl, *Zeit. f. Psychother. u. Med. Psychol.*, IV. Bd., 3 H., p. 146; also *ibid.*, 4 H., p. 232.

placed these questions (under (*g*)) in the 6th year (under his Development-tests, *l. c.*, Vol. II., p. 776). Binet has the child distinguish between morning and afternoon, and asks, "Is it morning or afternoon now?" Not until six, he concludes, is a child absolutely sure. Bobertag, nevertheless, found only 25 out of 55 (45 per cent.) six-year-old children could answer; 87 out of 126 seven-year-olds (or 69 per cent.).

This seems rather startling, for the question appears easy. There is no doubt, however, that the *time sense* develops late in children, and is not very clear for a long time. Ziehen[1] found that between the ages of six and eight children only know such time relations as are drilled into them through their daily routine, and especially that of the school; hence at eight they know the difference between hours and minutes, and also the half hour. But many went astray on the number of hours in a day (even at eight such answers were given as 19, 21, 60 and 23 hours). Ziehen states that for many children the day is not a measure of time, but only the opposite to night. To the question as to how many days a year contained, the answers varied from 20 to 160.

Though Meumann places these tests as stated above (in the 6th year), he nevertheless states elsewhere (Vol. I., p. 304) that he has convinced himself, through repeated questioning of five- and six-year-olds, that they do not understand complicated time conditions. If one says a thing happened yesterday or the day before yesterday or weeks or years ago, this is all merely a vague conception of something past for these children, and it is identically the same with time spans in the future. So if you promise a five-year-old a present fourteen days hence, or in a quarter of or half a year, it is all the same to the child—just something future. The six-year-old may tell you what happens in winter, in summer, etc., but does not grasp the span of time, or the idea of season, as such—or indeed of a quarter or a half year.

Do we ever consider this when we tell young children stories of 'once upon a time' or try to teach them history, or the biblical past? Therefore, we shall not lay much

[1] 'Die Ideenassoziation des Kindes,' Berlin, *l. c.*, p. 9.

stress upon our questions as to time, or take the answers over-seriously.

In testing *Form* (*h*) the De Sanctis set of cubes, balls and pyramids may be advantageously employed, as in tests No. 3 and No. 4 of his series,[1] *i. e.*, one mixes 5 cubes, 3 balls and 2 pyramids, chooses one of the lot, and asks the child to pick out a similar one, then repeats this, choosing another. One then shows a large cardboard on which there are pasted black silhouettes of balls, squares, cubes, triangles, pyramids, cones, crescents, oblongs, etc. The child is asked to point out, with a pencil all the figures which resemble the forms already shown him, and may also be asked for the names of the others on the cardboard. In this test *forms* are recognized, differentiated and recalled, and flat and stereometric figures distinguished. It is accomplished at six.

As a supplementary test to the above, one may employ the 12 cubes of different sizes used by De Sanctis in his fifth test, and enquire as to relations: *i. e.*, which is the largest, the smallest, neither one nor the other, the larger of two, etc. These cubes spread out on the table may be used in testing *space or distance*, (*i*), test I. One asks, "which is nearest, the most distant, point to one neither nearest nor most distant," etc. As test No. 5 in his series, De Sanctis asks, "How many are there, which is the largest, which the most distant?" the time, errors and omissions being noted.[2] One may also,

[1] Sante De Sanctis, 'Types et degrés d'insuffisance mentale.' *Année Psychol.*, XII., 1906. These tests are also discussed by Meumann, Vol. II., p. 325 et seq. See also, 'Mental Development and the Measure of the Level of Intelligence.' *J. Ed. Ps.*, 2, 1911, p. 498, etc. The apparatus may be obtained from C. H. Stoelting Co., Chicago.

[2] In test No. 6 of the De Sanctis series these same cubes are used; they are covered with something, and the child is asked: "Are the largest also the heaviest; are the farthest off the smallest?" This is a test of judgment, and one may give the test and mark it under judgment, among our combination tests in the next rubric. The ability of abstraction and generalization, according to De Sanctis, are also tested in this. The child who can answer these 5 tests, but not the 6th, has, according to De Sanctis, the highest form (the mildest) of feeble-mindedness. But for the adult feeble-minded, the 6th test has been found too easy—they may pass it. So the question has been modified thus: (*a*) "Do large things (les choses grandes) weigh more or less than little ones? (*b*) How does it happen that a small thing sometimes weighs more than a larger? (*c*) Do the distant things appear larger or smaller than the near ones? (*d*) Do they only look smaller, or are they smaller?" *A child passing this test cannot*

however, ask the child the same questions as to the furniture or things in the room. The test is accomplished at six to seven. One may then, test II., draw a line, and have the child divide it so that one part is larger than the other, then, equally in half. This test a child of six to seven can also manage. But when we have test III., a line to be divided in more complicated fashion, in proportions of 1 : 2 or 2 : 4, one finds that only from the twelfth year on is this problem correctly understood, and from the thirteenth carried out just tolerably well.[1] (The comprehension of space and distance in a picture, that is, *perspective*, is a more difficult matter, see further on.)

To test *direction* (*j*), we ask the child to point to the right, to the left (or right hand, left ear), in front, to the back, above, below, etc. Or one may ask (Ziehen): "What is downstairs? Who lives above you?" etc.[2]

*be feeble-minded, according to De Sanctis* (though he might be one backward in training, or an abnormal character).

De Sanctis' series is composed of six graded tests. Nos. 3, 4, 5, 6 are given above. No. 1 and No. 2 are as follows: No. 1. Six balls of different colors are shown and the child is asked "hand me the red (blue, etc.) ball. (The time taken is noted.) No. 2. The balls having at once been covered and mixed, are again shown and the child asked "Which ball (or balls) did you hand me?" According to De Sanctis, the child who gets no further than the second, has the lowest grade of feeble-mindedness; no further than the fourth, the second grade; no further than the fifth, the highest (mildest) grade.

[1] According to the experiments of Meumann and Giering the visual perception of distances (Raumstrecken) is developed early, and in children of six or seven years of age is almost as keen as in adults. Meumann found that from the 7th year on the test of halving a distance of 2 cm., was accomplished (in the cases he tested) with no error greater than 1/10th mm., in the most cases the error, in fact, being no greater than 1/20th mm. (Meumann, *l. c.*, Vol. I., p. 278.) The question as to which is the longer of two parts (the testor dividing them) is much easier. This may be answered even by defectives. So Ziehen notes ('Geist. des Kindes,' *l. c.*, p. 67) that it is strange how in cases of mental defect the relations-conceptions (Beziehungsvorstellungen) may often not be markedly affected, while the comprehension of colors and numbers is decidedly involved. "I know numerous strongly imbecilic children," he writes, "in whom conception of colors and numbers is almost entirely wanting, and who are able to choose from three paper slips of different lengths, the longest and shortest, or to arrange them correctly as to size." Ziehen also asks ('from memory'): "What is larger, a horse or a sheep," etc.

[2] A child may raise its right hand when it hears 'right,' and left hand when it hears 'left.' This may be automatic memory, each hand having received a name as it were. Through this memory, however, comprehension of direction may be aided. Binet thought one half the children passed his test at five, but that none failed

Tests for the comprehension of *weights*, (*k*), may be carried out in Binet's way. Small cubes of equal size but weighing 3, 6, 12, and 15 grammes each, are given to the child, who is asked which is the heavier (handing him first the 3 and 12 gramme cubes, then the 6 and 15 gramme). At the age of 9 the child is given the entire series, being of 3, 6, 9, 12, 15, and 18 grammes, and is then told that the cubes do not weigh alike, and that he is to place them in order, putting the heaviest first, then the next heaviest, and so on, down to the lightest. Three trials are made, of which two must be correct, nor should the operation take more than about three minutes (Binet).

The final test under *Comprehension* is that of (*l*) *pictures*. This most important test, however, entails comprehension only in the very young, and where the contents of the picture are simply enumerated as single facts, or described. According to Binet, the child at three simply recognizes and identifies the persons and things on a picture, and at the second stage, at seven, describes, giving the characteristics of the persons and things, these latter now being seen in some relation or association, and the description being accomplished with phrases instead of single words. But the meaning of the picture is not yet given. The next level (put at 15 in the revised scale), namely that of interpretation, necessitates combinative ability and therefore belongs in the next rubric (see Combination). It is this interpretative stage in the understanding of a picture that is the most interesting and important, and I have thought it best to reserve its elucidation as well as the general consideration and criticism of the problem of sizing up and grasping the meaning of pictures for our next report. This report will deal with Combination, Attention, Feeling, and Reliability of Memory.

at six. *Therefore it was a decisive test for him.* Bobertag, however, found that but 53 per cent. (only 29 out of 55) passed it, and, in fact, but 93 out of 126 seven-year-olds (74 per cent.). Hence Bobertag places this test in the seventh year. 'In front' and 'behind,' according to the latter, are grasped earlier, 'right' and 'left' being abstracter, while 'above' and 'below' are understood earliest of all, these (last) directions never changing for the child, while the others, if he faces about, are reversed,—hence more difficult to learn.

# THE MEASUREMENT OF THE EFFICIENCY OF MENTAL TESTS[1]

BY BEARDSLEY RUML

*University of Chicago*

The value of a mental test in selecting from a group of individuals those possessing certain academic or vocational abilities is indicated by the amount of relationship which has previously been found to exist between the standing of members of a similar group as given by performances in the test, and their standing in the ability tested for, as determined by the estimation of persons who are qualified to judge, or from the actual achievements of the individuals. In the academic field, when tests are given for the purpose of discovering the mental abilities of students, the standings of the students on the basis of the tests must be related with grades, or with the judgments of ability as given by teachers, before the working value of the tests can be stated. In business and industry, when tests are given to applicants for employment in order that those who are best fitted may be chosen, the efficiency of the tests can be judged only after the results as given by the tests have been compared with the abilities of the candidates, as shown by their subsequent achievements or by the judgments of their superiors.

This relationship, by which the value of a mental test is known, is too complex to be grasped by mere inspection of the data, and symbols of various kinds have been devised to aid in the interpretation of the facts. The most satisfactory measure of the relationship is the coefficient of correlation. As a result, the coefficient of correlation has been widely used in psychology as an indication of the worth of a test; yet when it is computed by the more common methods, *i. e.*, the product-moment method, the method of rank differences,

[1] Mental tests for 'intelligence' and for 'general ability' are to be distinguished from tests in the school subjects, such as algebra and reading tests.

and the foot-rule, it gives an erroneous idea of the true value of the test *in a certain kind of practical situation.*

In these situations to which we refer, mental tests have their greatest use as means of preliminary classification of individuals. The practical problem is to separate individuals into roughly homogeneous groups which will wait for their final internal arrangement upon the development of unmeasurable personal qualities. If a test is to be used in such situations, its value must be determined with reference to these situations. To correlate performance in a test with the exact evaluation of each individual's ability (the method of the three commoner formulæ) is to measure the test in terms of a problem which the test will never be called upon to solve—namely, the determination of the precise ability of each individual. If in the classroom, for example, all that is desired is the separation of students into fairly distinct classes of *good*, *mediocre*, and *poor*, there is no demand upon the test to rank the students in their actual order of merit. The final order of the students will be determined partly by factors which are clearly non-intellectual, and which no test would be expected to anticipate. In business the same condition obtains. The purpose of the test is fulfilled if it succeeds in merely picking out the applicants who are superior, allowing their industry and moral qualities to fix their final rank.

A still more concrete case may be worth describing. Suppose that we have ranked 500 college freshmen, first according to estimates of their ability by their instructors, and second according to their performances in a series of mental tests. The correlation between these standings, let us say, is +.50. The following year we might want to pick out freshmen at the beginning of the school year for advanced divisions in the freshman subjects. The question arises, "Is it possible to make the selection of the brighter students on the basis of their performances in the tests?" Although we know that the correlation between standing in tests and in judgments is +.50, still this coefficient does not tell us how well the tests will pick out a *group* of the more capable

students. For the coefficient +.50 is determined by relating the exact standings of each individual in the two series, standings in tests and standings in judgments.

Suppose the following standings of 16 individuals in the two series, the colon separating the number of individuals to be included in the 'good' group.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standing in tests..... | 5 | 4 | 3 | 2 | 1 : | 9 | 8 | 7 | 6 | 16 | 15 | 14 | 13 | 12 | 11 | 10 |
| Standing in judgments... | 1 | 2 | 3 | 4 | 5 : | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

Here, although the correlation by the method of rank differences is only +.61, the efficiency of the tests in picking out the 'good' group is 100 per cent. In other words, accuracy or inaccuracy of the internal arrangement of the groups is equally acceptable for the practical purpose of getting the best students into the advanced divisions. When tests are to be used in situations of this kind, they must be measured by how sharply they differentiate the 'good' as a group from the 'not-good' as a group. Such a measure would give the real practical value of the tests for the specific situation.

The measurement of a test by the true practical situation may be made by use of a formula published in 1907 by Karl Pearson.[1] Fortunately, the measure is exactly equivalent in meaning to the product-moment coefficient of correlation, and it is designated by the same symbol "*r*." Brown[2] in 1911 called attention to the formula. The exact description of the formula as it is stated in the title of the article in which it appeared is *A New Method of Determining the Correlation between a Measured Character 'A,' of which only the Percentage of Cases wherein 'B' Exceeds (or Falls Short of) a Given Intensity is Recorded for Each Grade of 'A.'* Thus the correlation between performance in tests and the general qualitative divisions of the group as judged may be determined; for the measured character '*A*' becomes the test measurements, and the character '*B*' given by alternative categories becomes the general qualitative divisions.[3] In the actual

[1] *Biometrika*, 7, 96–105.

[2] W. Brown, 'Mental Measurement.'

[3] Or vice versa, depending upon the information which is desired. If the alternative categories are based upon judgments, the coefficient will tell the value of the tests

situation, to be sure, there are usually three divisions—*good*, *mediocre*, and *poor;* but this difficulty is instantly overcome by dividing the group twice—once into the *good* and *not-good*, and again into the *poor* and *not-poor*. The formula is then applied for each division. In this way it is possible to tell whether the test works more efficiently in separating the *good*, or the *poor*, from the remainder of the group.

Important as the formula is in obtaining a measure of practical efficiency of a test, it has a still greater value. For it may be used to determine just where the division into classes should be made in order that the test may operate at its highest efficiency. Let us consider a group that has been divided into the *good* and *not-good* according to judgments. Clearly this division may be made at any point, and at each point of division there may be a different coefficient of correlation. If the changing values of the coefficient of correlation are plotted for the changing percentages of division (see charts) an excellent indication of the best point of division will be given. If the test is tried out for a sufficiently large number of individuals, 500 or more, this best point of division will be valid for all individuals of that class, and may be taken for use in all further work. The coefficient of correlation at this point of division is the indication of the true practical value of the test.

The presuppositions upon which the formula is based are linear regression—a presupposition for any correlation *coefficient*—and the Gaussian distribution in the alternative variable, here the judgments Strict normality is not essential for practical work but since the accuracy of the result will be affected by the distribution, the measure of the skewness of the curve should always be given whenever it can be computed.

The formula as stated by Pearson is

in selecting a certain percentage as judged. If the alternative categories are based upon tests, the coefficient will tell the relation between a certain percentage as tested and the judgments.

$$r = \frac{\frac{p}{\sigma_1}}{\frac{q}{\sigma_2}}; \quad \frac{q}{\sigma_2} = \frac{\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}(y/\sigma_2)^2}}{\frac{1}{\sqrt{2\pi}} \int_{y/\sigma_2}^{\infty} e^{-\frac{1}{2}y^2 dy}},$$

where $p$ and $q$ are the means of the two variates; and $\sigma_1$ and $\sigma_2$ are the two standard deviations.

In spite of the apparent complexity of the formula, the actual labor in application is very slight. The following ten simple steps will give the coefficient.

1. Determine the mean of the measured character.

2. Determine the mean of the members of the measured character included in the smaller class of the character given by alternative categories.

3. Determine the standard deviation of the measured character.

4. Subtract 1 from 2.

5. Divide 4 by 3.

6. Divide the number of cases in the smaller class by the total number of cases.

7. Subtract 6 from 1.00.

8. 7 equals $\frac{1}{2}(1 + a)$ of Sheppard's tables[1] of the probability integral; secure the corresponding $z$.

9. Divide 8 by 6.

10. Divide 5 by 9, which gives the correlation coefficient.

Tables of the probability integral (Sheppard's Tables) are essential.

The following problem illustrates the use that may be made of this formula.

Fifty college freshmen were given a series of mental tests. *Required*, (1) a measure of the efficiency of the combined tests; (2) the relative efficiency of the tests in separating the *good* and *poor* groups; (3) the percentage of individuals that should be included in each group in order that the tests may give the best results.

On the basis of the grades of the students, the group was

[1] *Biometrika*, II., or 'Tables for Statisticians and Biometricians,' edited by Karl Pearson.

divided into the *good* and *not-good*, by putting the highest eight per cent. in the *good* group. The correlation with standings in the combined tests was then computed by the formula described in this paper. Again the group was divided into the *good* and *not-good*, but this time the highest twelve per cent. were put into the *good* group. The correlation was found for this second division. Similar divisions were made at the 16, 20, 24, 28, 32, 36, 40, 44, and 48 per cent. points, and the correlation was computed at each division. A curve was then drawn showing the amount of the correlation at each of these points. (See chart.) A curve of the

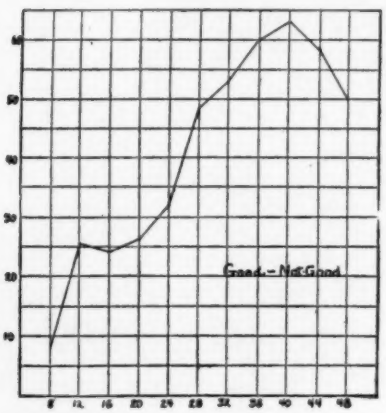


FIG. 1.
Vertical Axis—Coefficient of Correlation.

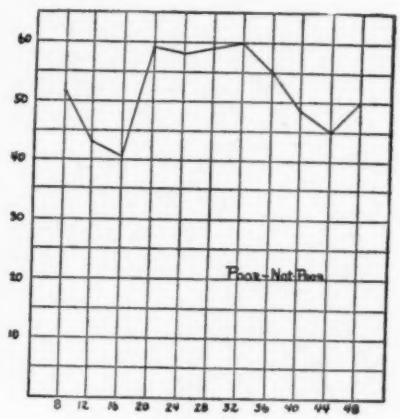


FIG. 2.
Horizontal Axis—Points of Revision.

various degrees of correlation when the group is divided into the *poor* and *not-poor* was obtained in a similar way.

From these two curves, it may be instantly concluded that if the *good* students are to be separated from the *not-good*, the separation had best be made at the forty per cent. mark, for here the correlation is the highest, +.63. In case the *poor* are to be selected, the division may be made anywhere from twenty to thirty-two per cent., and the correlation will be about +.58.

In contrast with these results, the only information which the product-moment formula gives from these data is that

the correlation is +.43, *a value that is erroneous if the tests are to be used only for separating the individuals into homogeneous groups.*

This problem is one of a type that is common in education, business and industry. Wherever it is necessary to evaluate tests that are to be used in the selection of groups of individuals, the formula described in this paper should be used; for it is then possible to determine what the practical efficiency of the test really is, to weigh the relative accuracies of selecting the *good* or the *poor* individuals, and to determine the best percentage that can be included in either the *good* or *poor* groups.

# PENDULUM AND INTERVAL TIMER

BY A. P. WEISS
*Ohio State University*

In psychological experiments in which a series of distraction stimuli are used, it is often necessary to regulate the duration and sequence of all the stimuli rather carefully. In auditory experiments where stimuli are to be compared successively or simultaneously, it is also important that the duration of the stimuli and the intervals between the stimuli be maintained constant.

There are numerous devices on the market for producing serial or multiple effects, but the apparatus herein described has proved so flexible in its range and so constant in its performance that a brief description seems warranted.[1]

The essential parts of the combination are:

1. An electrically driven duplex pendulum, Fig. 1. The period of this pendulum may be varied without interfering with the driving mechanism or the contacts. The aim in designing this pendulum was: ease of operation, reliability in action, and sturdiness in construction. Graduate students in psychology are often deficient in mechanical ability and flimsy apparatus soon becomes useless.

The pendulum is hung from a knife-edge placed at the middle of the pendulum rod. This knife-edge rests on a grooved steel plate which is fastened to the top of the shelf which carries the driving mechanism of the pendulum. Hanging the pendulum at its center makes it possible to shorten the rod, and by means of the double weights, increase the range of its period of oscillation.

2. A modified Kuhlmann interval timing apparatus, Fig. 4.[2]

[1] This apparatus was constructed by A. P. Freund, mechanician of the physics department, Ohio State University, from sketches and drawings furnished by the writer.

[2] The writer has been unable to locate the original article in which Kuhlmann describes his interval timer.

This is a ratchet device which is tripped magnetically by the pendulum. On an axle coupled to the ratchet wheel axle are mounted a series of sprocket or time wheels whose teeth make contact with a contact spring or brush and thus close an electric circuit. This circuit may then be connected to any kind of apparatus used to produce stimulation of a sense organ (tachistoscope, memory apparatus, adaptation hood, signal light, tuning fork, resonator shutters, telephone receivers or telegraph sounders, gusts of olfactory vapors, time markers, etc.).

The teeth and the spaces between the teeth are so arranged that any desired interval may be used. Six wheels may be used at one time so that six series of contacts may be made. This means that six independent electric circuits are all regulated by the same timing device.

The following are some of the characteristics of the pendulum and interval timer:

1. The pendulum is electrically driven and uses very little current. Its magnet is wound for 110-volt, direct current, and in operation uses about one tenth ampere.

2. The pendulum may be used alone for any of the uses for which a seconds' pendulum is ordinarily used, such as kymograph markers or signal magnets. It needs practically no attention when once adjusted, and if it does happen to stop it does not leave any of the apparatus short-circuited.

3. The current driving the pendulum is insulated from the tripper circuit which drives the timer or other apparatus, so that any short circuits or accidents in the apparatus do not interfere with the driving mechanism of the pendulum.

4. The period may be varied from 1 oscillation in 2 seconds, to 4 oscillations in 1 second. The period is adjusted by shifting the pendulum weights 4 (Fig. 1). For short periods (3 or 4 oscillations per second) the upper weight is removed and then the pendulum acts simplex.

5. Shifting the weights does not interfere with the timer or marker contacts since these are made by the end of the pendulum rod and not by the weights.

6. The length of the stroke of the pendulum can be

adjusted for larger or smaller angles. In general it is best to have the stroke as short as possible to do the work.

7. The pendulum may be arranged to make only a single oscillation with magnetic trip and automatic return. This involves a set of attachments which are not shown in the plates nor described in the article.

8. The current from the pendulum, which trips the interval timer, is independent of the currents which pass through the time wheels and control the stimuli or manipulate the experimental apparatus.

9. The time wheels can be easily changed without disturbing the ratchet mechanism. The phase in which the wheels are set relative to each other is also easily adjusted.

10. One of the time wheels may be used as a series control in the tripper circuit. This will enable the operator to start a series by pressing a key. After the series has been started it will continue automatically and then stop until the operator again starts the next series. In this way a single experimenter may handle an experiment which ordinarily may require two or more operators.

## Description of Details

Fig. 1 shows the pendulum complete, set up ready for use. Its height is about 3 feet.

Fig. 2 shows the driving mechanism of the pendulum in detail.

Fig. 3 shows the method by which the pendulum rod makes the contacts of the tripper circuit for the interval timer. These contacts are adjusted on the sector 24 (Fig. 1). They have been found much more satisfactory than the mercury cup ordinarily used for this purpose.

Fig. 4 shows a top view of the modified Kuhlmann timer.[1]

The pendulum rod 1 is made of an iron rod ⅜ inch in diameter with knife-edge 2 resting in a groove on the steel plate 3. The brass weights 4 can be adjusted up or down on the rod 1 by the set screws 5. It is by adjusting these weights that the period of the pendulum is regulated.

[1] The details of the mechanism are numbered and these numbers are the same both in the description and on the plates.

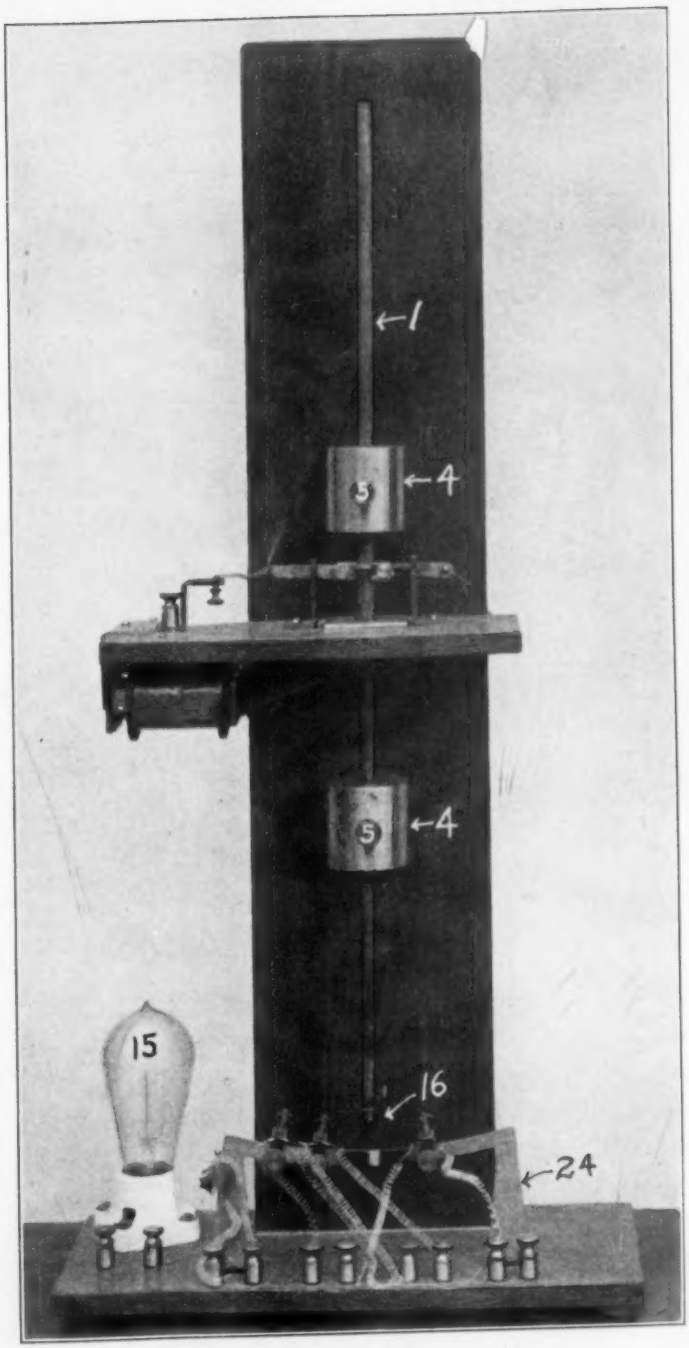


Fig. 1. Front View of Pendulum

The contact bar 6 slides in the guides 7 and makes contact with the plate 8 when the lower weight of the pendulum is to the right. The screws and stops 9 regulate the magnitude of the angle through which a magnetic pull is exerted on the pendulum rod, and this controls the amplitude of oscillation. The magnet 11 is connected with the contact bracket 10, so that when the bar 6 is in contact with plate 8 the magnet will pull on the armature 12. This armature acts on the pendulum rod 1 through the connecting rod 13.

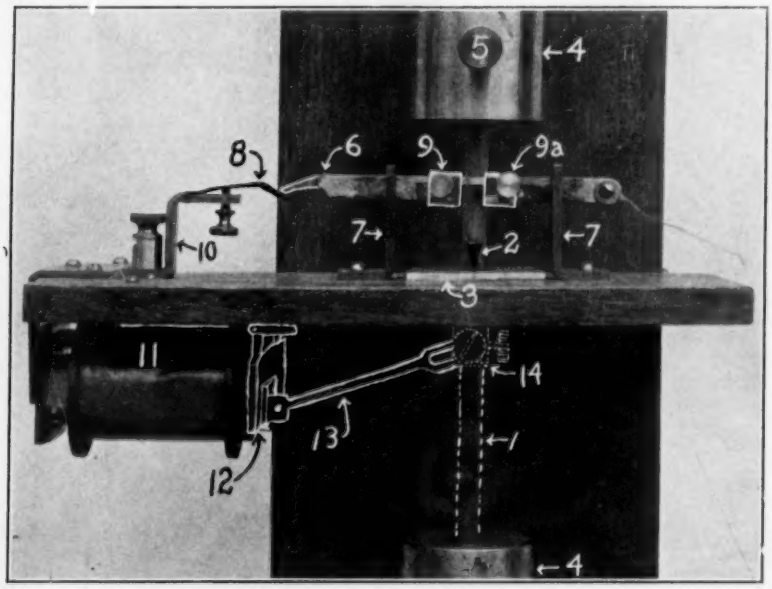


FIG. 2. Driving Mechanism of Pendulum

When the lower end of rod 1 has been drawn toward the left a short distance, an insulated pin in the rod 1 acts on stop 9*a* and draws the contact bar 6 off of the plate 8, thus breaking the electric current which is passing through the magnet 11. The remainder of the stroke is made by the momentum of the weights. This mechanism is practically noiseless in operation. The armature 12 hangs away from the poles of the magnet so that, as soon as the circuit is broken between 6 and 8, it swings freely without touching the magnet cores.

The end of the connecting rod 13 attached to the pendulum rod 1, acts on the clamp 14 which may be adjusted up and down. In this way the leverage of the magnetic pull can be varied. The electric light 15 is a 10-watt lamp connected in series with the magnet 11. At the lower end of the pendulum

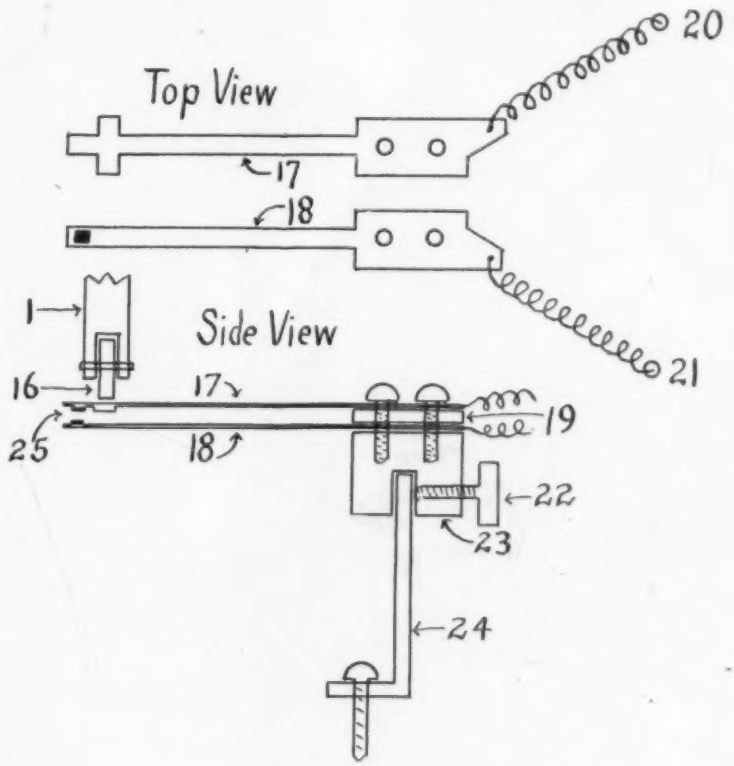


FIG. 3. Details of Tripper Contact

rod 1 is a small hard rubber roller which makes and breaks the circuit through the timer (Fig. 4) by the contacts shown in detail in Fig. 3.

These contacts are insulated from the pendulum mechanism and from each other, and any number may be used without danger of short circuits. Increasing the number of these contacts has the same effect as increasing the period of the pendulum.

The thin bronze springs 17 and 18 make contact at 25 when the rubber wheel 16 passes over plate 17. The contact surfaces 25 are small pieces of silver soldered on to the bronze. The plates 17 and 18 are insulated from each other by the fiber plate 19 and are independently connected

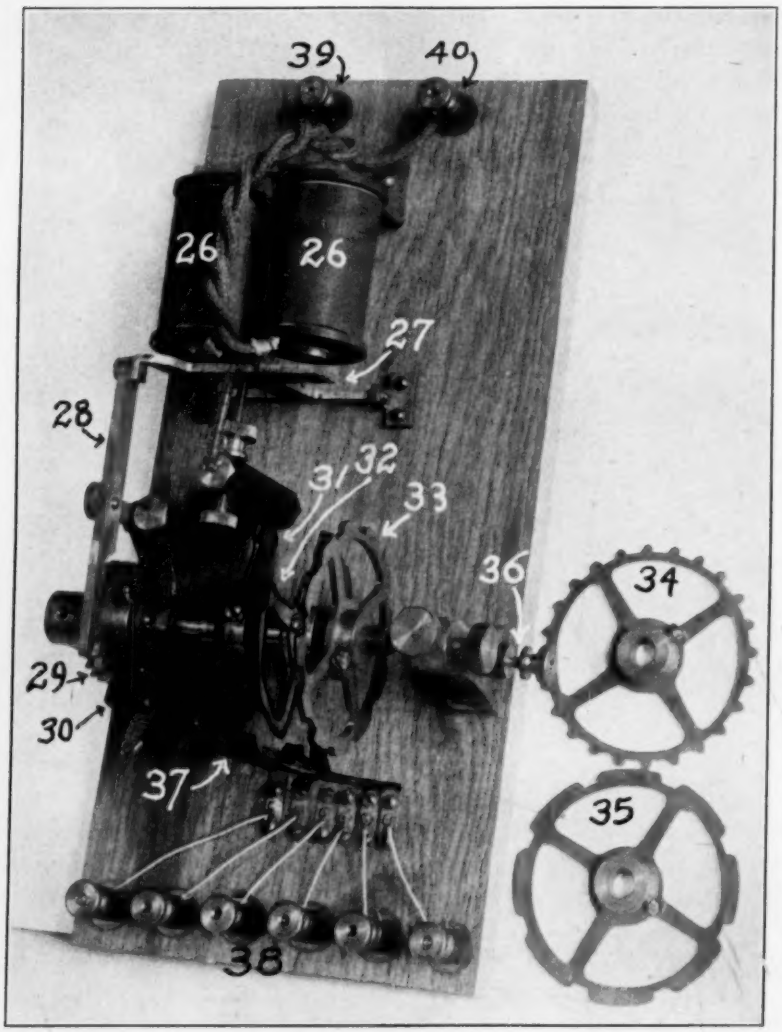


FIG. 4. Top View of Interval Timer

to the binding posts 20 and 21. They are screwed to the brass clamp 23 which can be fastened in any position on the sector 24 by the screw 22. This mechanism makes it possible to close a circuit at any point in the stroke of the pendulum, or where a number of contact clamps are used, to regulate the intervals between contacts. Such adjustments are of greatest value where the pendulum is used as a single stroke pendulum with automatic return.

The circuit which is closed by the pendulum contact 25 is connected to the binding posts 39 and 40 (Fig. 4) and then passes through the timer magnet 26 which acts on the armature 27. The ratchet bar 28 attached to the armature, engages the teeth of the ratchet wheel 29 and moves it one tooth every time the magnet is tripped by the pendulum. The back stop 30 holds the ratchet wheel stationary while the ratchet bar 28 makes the return stroke. The time wheels 31, 32, 33, are mounted on an axle which is coupled to the ratchet axle.

There are 24 teeth in the ratchet wheel and this means that 24 trips of the magnet are necessary to make one complete revolution of the time wheels. The circuits which operate the apparatus used in experimentation, enter the binding post 36 and pass into the time wheels through the axle. The sprockets or teeth of the wheels close the circuits through the bronze spring contacts at 37 and the current then passes to the respective binding posts at 38 and finally to the experimental apparatus. All contacts are designed to work satisfactorily up to 2 amperes on 110-volt circuits. For higher voltages and heavier currents relays should be used.

The time wheels shown in Fig. 4 operate as follows if we assume that the pendulum is set so that it trips the timer once every second:

Time wheel 31 will close a circuit for 1 second and leave it open for 11 seconds; wheel 32 will keep a circuit closed for 3 seconds and open 9 seconds; wheel 33 will keep a circuit closed 1 second and open 1 second; wheel 34 will give an instantaneous current once every second; wheel 35 will

close a circuit for 2 seconds and keep it open for 1 second. As may readily be seen many other combinations of 'open and closed' circuits are possible, especially if the time wheels are operated in tandem.

In an experiment which is now being performed, in which the pendulum and interval timer is being used, it is necessary to present two tones, each one of them twice. One tone is to start as soon as the other stops and the duration of the tones must be 1 second each. To do this satisfactorily by a manual method is practically impossible because it is necessary for the experimenter to record the judgments of the observer and also change the intensities of the tones. By the aid of the combination herein described it is only necessary that the experimenter depress a key long enough to start the series. The tones are then presented accurately as to duration and sequence and the apparatus completes the series automatically and sets itself ready for the next presentation.